FEILDEN'S MAGAZINE.

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Britain's One-Sided Policy.

What of the Future?

We have on more than one occasion emphasised our opinion that if Great Britain once starts acting upon the information gathered within the last two or three years, and rendered accessible to all and everybody, concerning the actual conditions of industry and commerce throughout the world, she is sure to recover lost ground and to secure a firm position in the front rank of the most progressive nations for many years to come. The individual qualities of her inhabitants weigh as heavily in the balance to-day as ever before; the natural resources of her Colonies, combined with the loyalty of the Colonists—a loyalty that exceeds even the most sanguine hopes of the Mother Country, and can be realised only by those who have lived amongst them—are a basis to build upon, more solid than that underlying the prosperous conditions for the time being of her most formidable rivals; and her liberal institutions and her form of government, infinitely in advance of all other nations of our time, must secure a constant influx of the very highest type of foreign settlers, forming more than a sufficient counterweight against thriftless and incapable emigrants that, unfortunately, also profit by a liberty of which they little understand the use. All in all, we repeat, Great Britain's prospects in the fields of industry and trade are as bright as ever before, provided—and this is a serious provision—she resolves, as above said, to act and to adapt her action to the existing state of affairs revealed to all who have open eyes by the exhaustive discussions of the situation both in the political and technical press of this and other countries. To close her eyes to the truth would be fatal, of course, and for this reason it is deeply to be regretted that even Englishmen of so high an intellectual type as the President of the Associated Chambers of Commerce should think it expedient to awaken optimistic views among his fellow-countrymen by statistics that do not admit of rigorous investigation. By comparing the British exports of 1900 with those of 1895, and by omitting to mention the fact that the export of new ships was for the first time included in our export returns of 1899, he is able to say that our exports last year exceeded those of the preceding year mentioned by £67,000,000. Lieutenant Carlyon Bellairs, who draws attention to these facts, in writing to a contemporary, accuses Lord Avebury of having apparently "forgotten" the point of the "new ships." We think that this is but a poor compliment to a scientific author of Lord Avebury's attainments, and have no doubt that he was fully aware of the facts; nor have we the intention of suggesting a desire on his part to mislead his hearers. The incident is fully explained by Lord Avebury's desire, clearly stated in one of his most deservedly popular books, to arrive at truth by suppressing an innate tendency towards pessimism. Unfortunately a good many of his fellow-countrymen hardly require the correction, and we think it far more expedient to force them to look upon the true facts, however unpleasant, namely, that after making allowance for the different bases of the returns of the two years quoted, the increase of exports of British produce and manufacture amounts only to 56·5 millions, which is, to quote our contemporary, only a little in advance of the 55 millions of Germany, and that a factor worth noting is the circumstance that this increase in our exports is due very largely to coal and coal products, which alone represent 23 millions of the total, while the increased exports of our rival represent practically only manufactures. And we also agree with Lieut. Carlyon Bellairs

that the comparison of the exports of the two years selected is very misleading when, if the year 1896 had been chosen instead of 1895 the British increase would have had to be quoted as less than 43 millions, as compared with an increase of 60 millions sterling in Germany. Nothing is to be gained, to our mind, by sugaring the bitter pill that is to cure us of our semi-comatose condition in recent years; it is much better that it should be tasted while taking. But when it has done its work it is of high importance to prevent a recurrence of the unhealthy condition, and we are convinced that for this purpose it will be absolutely necessary to modify our mode of life. A policy of absolute unselfishness, and the proud boast that we can get on without the long-expected but still far-off reciprocity on the part of others, may be all very well in theory but not in practice. Our stubborn free-trade policy may be magnificent, but does it meet the needs of the present eminently prosaic age, and will not our political leaders, if they continue it without modification, be as justly accused of criminal blundering as the authors of the charge of Balaclava? Pure free trade is an admirable policy theoretically; but maintained by one nation against all it surely becomes a parody of the ideal. Ideals have to be modified on this earth of ours if an attempt is made by us to live up to them; if not, they become a mockery. All that is needed to grasp this fact is a comparison between the republican government in theory—the most ideal of all, if man were perfect—and its existing realisations on earth.

The Editor of FEILDEN'S MAGAZINE, whilst not absolutely pledging himself to any rapid revolutionary change, is of opinion that there should be no longer delay in the pursuance of a vigorous and aggressive line of action with a view to the modification of our fiscal arrangements, called for by the altered conditions of the times. He therefore invites, as a preliminary, criticisms and opinions from his numerous readers, with a view to a campaign which can rightly be described as of truly pressing National importance.

An important article on the subject will appear, from the pen of the principal of one of our leading engineering firms, in the next issue of FEILDEN'S MAGAZINE.

The London Chamber of Commerce and Electrical Power Supply.

In February last, in consequence of the situation created by the passage of the Electric Power Acts of 1900, an Electrical Power Mains Regulations Committee was appointed by the Electrical Section of the London Chamber of Commerce. Their report has now been published as a blue book, and contains, in addition to the report itself, a memorandum addressed to Mr. A. P. Trotter, Electrical Adviser to the Board of Trade, and an appendix compiled by Mr. E. G. Cruse, the Technical Secretary to the Committee, dealing with the Government laws and procedure regulating electric power supply in Switzerland, Germany and France, together with the safety regulations in general use in these countries, and also in the United States of America, where there is no supervision of the industry on the part of the Government.

The memorandum comprises six recommendations to be put before the Board of Trade. They all represent well-considered and eminently desirable relaxations of the bonds which have fettered the electrica industry in this country, and transferred it from its former proud position in the van of the march of electric progress to that of a straggler in the rear. The gist of these recommendations is as follows:—

1. That there should be no hard and fast limits to the pressure permitted in distributing systems, but that where it exceeds 20,000 volts the committee considers that undertakers might reasonably be asked to specify in detail, for the approval of the Board of Trade, the character of the extra precautions they propose to adopt.

2. That limitation of the size of mains, or of the output which they may carry, is unnecessary and incompatible with natural development. It is suggested that undertakers should be required to arrange their systems of mains, as far as possible, in such a manner as to provide an alternative route in case of accident. It is also proposed that where more than 2,000 kilo-watts are to be habitually transmitted by one main the undertakers should be required to notify the same to the Board of Trade for the purpose of record. Also that after exceeding a capacity of 8,000 kilowatts a central station should not transmit more than one-fourth of its total energy by one set of

mains without notification to the Board; but that not more than two sets of mains should be required up to 4,000 kilo-watts.

Alluding to the present regulations, not more than 300 kilo-watts may be carried by an underground cable, and not more than 50 kilo-watts by an aërial line, except by special permission of the Board of Trade. There is, however, no special provision for an alternative route to provide against breakdowns. The result is that where a large amount of power has to be carried a number of cables are employed, which greatly increases the expense while providing very little additional security against breakdowns, for the cables are usually grouped together, so that in the event of an accident the whole group is generally thrown out of use.

The proposed alteration would therefore be beneficial both to the undertakers and the consumers.

3. That with regard to the laying and protecting of cables the regulations should be open and elastic as the Committee consider that considerable improvements may be expected in this direction in the near future, and that experiment, development, and invention would in all probability be greatly hampered by the laying down of rigid rules in the present state of our experience.

They also ask

that where the conductors are interwoven into a single cable, and where the neutral point of the system is earthed, the use of a metal sheath in addition to the lead covering should be optional, provided suitable mechanical protection is afforded.

The intention of the concluding suggestion is evidently that where there is no outer to be put to earth, as in a three-phase interwoven cable, for instance, undertakers should not be compelled to provide sheathing which was designed for efficient earthing of the outers, and which in such a case would not only be useless but would give rise to a very sensible loss of energy.

4. That undertakers and cable-makers should be allowed to settle among themselves the thickness of dielectric to be employed, as the present Board of Trade rule is both unscientific and unpractical.

These strictures on the present rule are fully justified, and it would be impossible to make out a case for retaining it on any rational grounds. It might be urged with truth that it is distinctively British, since no other countries have adopted it. The same argument might, unfortunately, be advanced in favour of a good many of the restrictions which have weighed so heavily on British electrical industry.

5. That the onorous restrictions which have hitherto practically prohibited overhead work in the United Kingdom should be removed, and facilities given for their use outside crowded city areas, as is done in every country but our own.

6. That high-pressure transformers should be allowed on consumers' premises in sub-stations above or below ground, provided they are properly designed, drained, and ventilated; and that the amount of power to be installed in sub-stations should be left to the undertaker's discretion.

The Committee explain, in their report, that these suggestions were drawn up after careful consideration of the regulations in force in the countries referred to above, which, they point out, are, taken as a whole, more favourable to the free development of undertakings of this nature than the existing regulations in Great Britain.

The Swiss regulations, including acts at present pending, are given in considerable detail. As might be anticipated from the close relations existing between the Swiss Institution of Electrical Engineers and the Government Department dealing with electric power supply, to which reference was made in a recent leader, they are drawn up in such a manner as to fully secure the safety of the public and prevent improper interference with other interests, without laying any unreasonable burdens upon the electrical industry.

Installations are divided into low-power and high-power installations, the former being defined as those which involve no danger to persons or things, while the latter are those which may do so under certain circumstances.

This is a much more sensible classification than the one adopted in this country of low-pressure, high-pressure and extra high-pressure installations, according to whether the pressure does not exceed 500 and 3,000 volts respectively, or is in excess of the latter. The possibility of danger to persons and things depends on the power carried as well as on the voltage, though the danger to life is practically dependent on the latter.

In France, as in Switzerland, the State holds control over the supply and transmission of electrical energy. The conditions generally are comparable to those of Switzerland, the regulations having been drawn in a very similar manner by a standing electrical committee appointed by the Government, and on which the electrical industry is strongly represented.

In Germany, electrical power transmission schemes can, generally speaking, only be carried out after the issue of a special licence in accordance with the decrees of the German department of industry and commerce, and the governments of the different States, these being granted under conditions imposed upon the undertaking in the interest and for the safety of the public and the employees.

There is at the present time a tendency towards imposing direct Government supervision and control, and the German electrical industry is doing its utmost to prevent this from being carried out.

Dissensions Regarding the Basis of Atomic Weights.

PERHAPS it is merely a tempest in the tea-cup, but, all the same, the dispute regarding the basis of atomic weights in Germany cannot be entirely ignored, were it merely to show how often even men of the deepest learning raise a working theory to the undeserved dignity of a scientific fact. Not so very long ago, the German Electro-Chemical Society, at its general meeting at Zürich, adopted unanimously the atomic weight of O = 16,000, in agreement with the international scale. Meanwhile, however, a circular drawn up by a number of well-known academical teachers of chemistry was sent to scientific teachers in the various German universities, asking them for an expression of opinion on the atomic weights to be fixed for oxygen and hydrogen respectively, the result being that of a total of 104 only 19 voted for O = 16,000, while all others declared themselves in favour of H = 1,000. At a first glance this seems a somewhat conclusive argument in favour of adopting the latter basis, but the opinion of academic teachers alone can scarcely be called decisive in a question which is of international interest and concerns practical chemists equally with theoreticians.

The arguments of the supporters of the academical view are, as the official organ of the electro-chemists in Germany shows, by no means conclusive. To mention one case in point merely, Herr Lassar-Cohn supports his objection to O = 16,000 by making the statement that the brilliant achievements of the indigo and the sugar synthesis have had for their basis the scale of atomic weights in which H equals 1. An even superficial inquiry suffices to shew that these achievements very little agree with the alleged basis from which they started, for the hydrogen percentage in sugar, if C = 12, H = 1, and O = 16, or rather 15·96, is found to be 6·43 or 6·44 respectively, while on the basis of the new relation of H O we get the correct figure, equal to that experimentally obtained, namely 6·49 per cent. We can congratulate ourselves that the splendid result of the sugar synthesis was obtained notwithstanding the inaccuracy of the basis, but, in reality, this synthesis is quite independent of any figure that may be selected as a basis. The plea of the opponents of O = 16,000 that there will be educational difficulties resulting from a revision of the basis of H = 1 is, as our contemporary shows, of no weight whatsoever, since similar deviations have been adopted, without leading to confusion, in the science of pneumatics and in treating Gay-Lussac's law referring to the combination of gases by volume. On the contrary, an explanation given to the students regarding the inaccuracies of the basis formerly adopted and the change considered necessary owing to the deeper insight we have obtained during the course of experience, would give to a judicious teacher the welcome opportunity of impressing upon them the important fact that the so-called atomic weights have but relative and no absolute value, and that it is quite indifferent what figure may be selected as the standard of comparison. The selection of hydrogen, the lightest of

the elements, as equal to unity, instead of the preceding figure of O = 100, had for its sole reason the desire to obtain in the list smaller and simpler figures, and to avoid, as far as possible, fractions. The same desire for simplicity has been the cause of adopting O = 16, which permits us to render the relative atomic weights still simpler, as far as their decimals are concerned, not to speak of the strong arguments in favour of the adoption of this basis, that can be derived from the science of measurement. In conclusion, to retain H = 1 and O = 15·88 in spite of our more accurate knowledge is not only an anachronism, but is equivalent to wilfully ignoring the fact that the figures for the hydrogen percentage in organic analysis, whenever any one of the new atomic weights is adopted, are always inaccurate by about 0·8 per cent. All these, and other reasons, should induce the ultra-conservatives in this branch of chemistry to surrender at the earliest possible moment in favour of the international list of atomic weights.

Brooklyn Suspension Bridge.

COMPARATIVELY little notice has been taken in this country of the recent mishap to the well-known bridge between New York and Brooklyn. The original designers of the structure must be given every credit for a magnificent work that has been a monument of engineering skill for many years past, although it seems to be the fact that some slight defects of design have existed from the very first. These blemishes are to be found in the situation of the expansion joints at the centre of the main span, and in the failure of the suspension rod connections to provide for the necessary and corresponding amount of longitudinal movement. The movement of the main girders is at the maximum just at the point where the length of the suspenders is at the minimum; consequently the latter members have little flexibility, and avoidance of injurious strain depends entirely upon the efficiency of the trunnion joints by which they are connected to the girders. As a matter of fact, several of the suspenders have failed, thereby dangerously affecting the safety of the bridge. It cannot be pleasant, although it may be instructive, for Americans to examine the causes which have revealed the defects in question. In the first place, it should be observed that the addition of two new passageways and the establishment of trolley tracks thereupon have indubitably imposed severe and wholly unwarrantable strains that were never contemplated by the designers. Secondly, it is admitted that the system of inspection has been lax and inefficient for years past. American engineers undoubtedly understand the art of bridge building, and it may therefore be presumed that they were fully acquainted with the structural defects to which we have directed attention. Consequently it is all the more astonishing that the points of weakness should have been neglected to such an extent as to permit the trunnion joints to be corroded and clogged up, and several of the suspenders to be rusted away and finally to be fractured by the bending strains produced. The American technical press is practically unanimous in condemning the supineness of the responsible engineers, and now that attention has been directed to the subject in so unfortunate a manner there can be no doubt that proper steps will be taken for the partial reconstruction of the bridge, and that suitable measures will be adopted for guarding against the neglect of necessary precautions in the future. We are sometimes told that Americans do not wish their engineering productions to last too long, for fear that they may become out of date, but it is to be hoped that this principle will not be applied to bridge building and similar works

The Proprietors of FEILDEN'S MAGAZINE desire to announce that, with a view to providing its large circle of readers—already, it can be safely said, the most extensive of its kind in the world—with an increasingly valuable production, they are arranging for important changes in the New Year along the line of progress.

Owing to the advancing demand for copies, Subscribers are advised to book up early to ensure complete volumes.

Enterprising firms, with a view to extension of trade and a good position in our pages would also do well to arrange as soon as possible for a series of Advertisements in the Magazine for 1902.

A New Industry for New South Wales.

THE discovery of bauxite deposits in New South Wales must be considered of the greatest importance to that colony and even to the Mother Country. Bauxite is now one of the most valuable mineral ores, as from it is produced all the metallic aluminium of commerce, and until this discovery was made the only part of the British Empire containing known deposits sufficiently extensive to be worked commercially was Ireland. Other deposits now being worked are found in France—at Baux, whence comes the name given to the ore—in Austria, and in the United States of America. The special value of bauxite lies in the fact that while in the other aluminium ores the metal is usually present as a silicate, which is extremely difficult to reduce to the metallic form, this ore contains the metal as an oxide, and is thus in a suitable form for reduction. Other metals, or their salts, are usually present as impurities to a greater or less extent; but taking the average for the deposits now being worked commercially, about 56 per cent. consists of alumina. The newly discovered ore would appear, therefore, to be of very good quality, for some of the specimens have given on analysis as much as 58 per cent. of alumina. In addition to this, we are told by Mr. Jaquet, the Geological Surveyor to the Government who made the discovery, that the ore has been found "in enormous quantities," so that we have good reason to hope that an industry which is daily growing in importance may soon be introduced into the colony.

The history of the manufacture of aluminium affords a striking illustration of the changes that have been wrought of late years by the introduction of electrical in place of purely chemical processes. This metal is distinguished from all the other metals of commerce by the fact that all of it is now produced by an electrolytic process. Electrolysis is, of course, used for the recovery of other metals than aluminium, as, for example, in the recovery of copper and still more in the refining of copper; but the distinction is that with these other metals electrolysis has to compete with other successful processes, whereas with aluminium no other process is successful. It is possible, in the case of most metals used in the industries, to reduce the ore by smelting in a furnace, but the heat obtainable there is quite inadequate to reduce aluminium ores. The only means of obtaining sufficiently high temperatures for this purpose is by using electricity; then, when the ore has been fused, an electric current is passed through the igneous solution to electrolyse it. Yet twenty years ago no one thought of producing aluminium electrolytically. It was then recovered from cryolite by a purely chemical process, which was so expensive as to make it impossible for aluminium to compete with other metals in their applications to industrial and domestic uses. The development of electro-chemistry, has, however, entirely altered the circumstances, and to-day aluminium can be produced at a price which makes it possible to take advantage of its valuable properties. In 1886 it cost £2 10*s.* per lb., and the production in the United States of America did not exceed 3,000 lbs. In 1897 the metal could be obtained for 1*s.* 4½*d.* per lb., and the same country produced 4,000,000 lbs. from bauxite ore." That the demand for aluminium will continue to increase steadily is practically certain when we consider the extent to which it is now being used in place of copper for electrical conductors, such as cables. The American Postal Telegraph Company is now using aluminium for all its new lines across the Atlantic. Among land cables, again, for the transmission of electrical power, there is already a line of aluminium, 100 miles in length and transmitting 22,500 h.p., running between Kansas City and Leavenworth; while another line, 22 miles. long and transmitting 10,000 h.p., has just been completed between Niagara and Buffalo. Everything, therefore, seems favourable, and nowhere will the promise of further development of the natural resources of New South Wales be welcomed more than in the Mother Country.

THE INTERNATIONAL ENGINEERING CONGRESS AT GLASGOW.—2.

THE tabulated results of the researches in the Variations of Carbon and Phosphorus in Steel Billets referred to at the conclusion of the previous article are somewhat surprising, the difference between the analysts being much greater than one would have anticipated. It must be borne in mind, however, that the analyses were made in the ordinary routine of the laboratories and no special precautions were taken. The discrepancy shows that if comparative results, obtained by the ordinary rough methods of routine work, are required from different chemists, it will be necessary to agree upon standard methods; and Mr. Wahlberg, on the discussion of his paper being opened, asked the meeting to pass resolutions to the effect that, first, standardised methods for general use should be agreed upon internationally; and, secondly, that the limit of variation of carbon should be 0·05 above or below the desired percentage, and that phosphorus should not be more than 0·02 above the prescribed amount.

Mr. J. E. Stead, member of the Council, and one of the four analysts above named, expressed the opinion that chemists would probably arrive at more concordant results in the future as the outcome of a more elaborate inquiry in view of the critical consideration of results given, and suggested that the four chemists who had previously been charged with the work should interchange their methods, all trying each other's system and reporting their results a year hence. The committee might then select any particular standard for general adoption.

The Mining Section.

Among the papers of interest read in the Mining Section may be mentioned that read by Sir William Thomas Lewis, giving a short review of the coal-mining industry. Sir William, among other matters, made the gratifying statement that the loss of human life from accident in coal mines had diminished from 19 per million tons raised in 1851 to 4 last year.

Another portion of the paper referred to economy, which, as we have pointed out elsewhere, is essential when progress in engineering methods is desired, and the economy, to which the author specially alluded, was that which results from avoiding waste. He wisely emphasised, in view of the growing competition with our coal trade, the necessity of seeking with all diligence for improved as well as cheapened methods of working, and blamed those lessees who work out only the best seams of coal and leave the thinner ones in the ground, concluding his paper with the remark, that whatever view was adopted it was our duty not to waste the mineral wealth represented by our coal mines.

A very satisfactory sign of the times, showing that the benefits conferred upon our country by scientific engineering methods begin to be comprehended, was the announcement made by

Mr. James S. Dixon,

coalmaster, of Glasgow, who succeeds Sir W. T. Lewis in the presidential chair of the Institution of Mining Engineers, that he had placed at the disposal of Glasgow University the sum of £10,000 to endow a lectureship. He remarked that it had been his intention to give this sum for the endowment of a chair of mining in the University, but he had been informed that such endowment would require about twice the amount at his disposal at present. He therefore had decided to endow merely a lectureship for the time being, as he had been informed that if, after five or six years, this endowment should prove to have been successful, he could supplement the £10,000, either himself or with the

assistance of others, until the full amount required for a professorship was completed.

Municipal Engineering.

Section 7, appointed to deal with the problems of Municipal Engineering, under the direction of the Incorporated Association of Municipal and County Engineers, also had the good fortune of gathering valuable information on many points of interest for its members, notably regarding the best methods of sewage disposal, to the knowledge of which mainly Lieut.-Col. A. S. Jones, V.C., and Mr. K. F. Campbell in their respective papers contributed.

Among the papers submitted to Section 8, the members of which met for the purpose of discussing important technical problems connected with the generation and distribution of gas, a sketch prepared by the committee, and describing the various systems of gas lighting represented at the Exhibition, may be mentioned, as it must have been of great help to visitors. Not containing, however, anything new to the profession, it was taken as read. The most important contribution, perhaps, was the paper on "Water-gas as an Adjunct in the Manufacture of Coal Gas," by

Professor Vivian B. Lewis,

the well-known expert on the subject, which gave rise to an interesting discussion.

In concluding this rapid review of the technical literature presented at the International Engineering Congress, there remains barely space for a few lines regarding

Mr. W. Langdon's Presidential Address

to the members of the Institution of Electrical Engineering, representing Section 9, to which otherwise we should gladly have devoted a few pages, as it incidentally deals with an important moral factor in the development of engineering methods in this country—namely, the attitude of our workmen towards the increasing use of machinery in place of manual labour. In Mr. Mansergh's paper, though the author devoted a fair portion to the causes of the successful competition of foreigners, this point was entirely omitted, and our temporary defeat was attributed to the absence of standardisation. The cause given by Mr. Langdon is, to our own mind, the far more weighty one of the two, especially as regards its effect upon the use of electrical energy in this country. He shows, supporting his assertion by figures, that the amount of electrical plant imported by us from the United States can by no means be treated as *une quantité negligeable.* Out of steam engines representing a total of 300,000 h.p., a portion representing 73,000 h.p. is imported from the United States alone for lighting and traction, and of electric generators, representing a total output equal to about 267,000 h.p. (200,000 k.w.), a number equal to 94,666 h.p. (71,000 k.w.) come from the same source. Nor is the whole of the remainder necessarily of British origin. That it is high time to do something in the matter nobody will deny, nor does anyone doubt that we possess all that is required to stand our ground with any manufacturing nation on equal terms, but, as Mr. Langdon points out, unless our workmen are willing to work, and are permitted to work, we must remain at a disadvantage. Were it not for the tyranny of the labour unions in this country, hundreds of thousands of British workmen would be willing to work with the same energy as their American colleagues, and if his remuneration depended on the industry and ability of the labourer, we would soon have among us men earning wages as high as those paid in the United States for special merit. The labour unions in England, however, will not tolerate special merit, and the aim of their leaders is to keep the output at the lowest level, under the illusion that this will secure employment to the greatest number. They forget, however, that if this state of affairs continues the British manufacturer must go to the wall, for he cannot compete under such conditions with his rivals, who have the advantage of an abundance of natural resources and of superior workmen to transform them into marketable commodities. We fully agree with Mr. Langdon, that what we need is absolute freedom for those who are willing and able to work, and the protection of this superior element of the working population against the ignorant and idle.

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Supplement to
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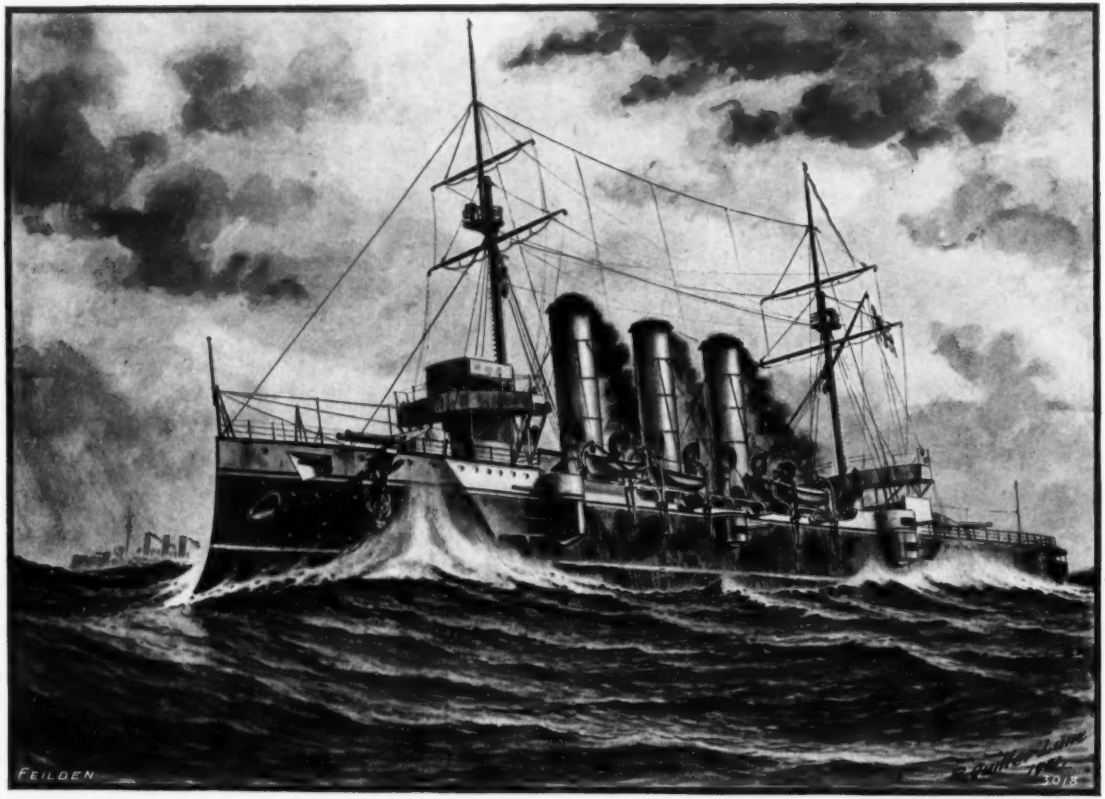
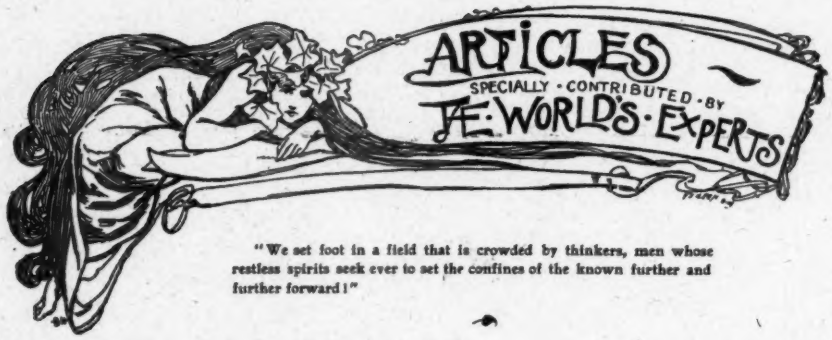


THE FIRST-CLASS CRUISERS "ESSEX" AND "BEDFORD."
TWO OF THE TEN IN THE "COUNTY" CLASS.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

The Structural Strength of Loco-Type Boilers.

By W. D. WANSBROUGH.

THE locomotive boiler, though a highly complex structure, is readily divisible for purposes of investigation into its elements of flat and curved surfaces. The object of the designer is to assign to each of these elements a sufficient sectional area of material, properly disposed to safely resist the intended working steam pressure.

To safely resist! We are thus driven at the outset of the subject to seek a definition of that important adverb. The "factor of safety" is the term employed to designate the ratio between the actual working pressure and the calculated ultimate strength of the boiler when both are expressed in the same units—pounds per square inch, for example.

What this ratio should actually be is a matter of opinion and experience. In some countries it is settled by law. In Great Britain you may, if you are prepared to take the consequences, put it at anything you please; provided your boiler be not intended for use on board a steamship carrying passengers, in which case the Board of Trade prescribes with great minuteness the factor of safety applicable to the case.

The table on next page, abstracted from the Board's "Regulations and Suggestions as to the Survey of Steam Ships carrying Passengers," will give us a lead which we cannot do better than follow.

The factor of safety will be 5, under the following conditions, viz.:

1. Best materials.
2. All rivet holes drilled in position.
3. All joints butt, with double straps.
4. All seams double-riveted, with an allowance of not more than 75 per cent. over single shear.
5. Full inspection during construction.

When these conditions are not observed the factor of safety will be increased as Shewn in the table on page 416.

It will be seen that the greatest offence, measured by the Board's increase in the *F.S*, or factor of safety, is that of constructing a boiler without the Board's continued supervision. The design, materials, and workmanship may be all that is desired, but 1·65 added to the *F.S* is the penalty for non-inspection.

However, we will take the liberty of omitting this; and, submitting to an addition of ·2 for single riveted lap joints in the cross seams, proceed to construct a steel boiler on the basis of a calculated *F.S* of 5·2, and for an intended working pressure of 150 lbs. per sq. in.

THE BOARD OF TRADE'S RULES FOR THE FACTOR OF SAFETY.

Additions to the Factor of Safety for			After Bending.	Before Bending.	Riveting.		
					Single.	Double.	Treble.
Longitudinal Seams.	Drilling out of place	...	·15	·3	...	...	...
	Punching	...	·3	·5	...	...	...
	Holes not good or fair	...	·75	...	...	...	...
	Lap joints	...	..	...	..	1·0	·2	·1
	Butt joints, single strap	...	...	...	.	1·0	·3	·15
	,, ,, double strap	...	...	...	...	1·0	...	...
Circular or Cross Seams.	Drilling out of place	...	·1	·15	...	...	...
	Punching	...	·15	·2	..	...	...
	Holes not good or fair	...	·2	...	...	...	...
	Lap joints	...	...	...	·2	·1	...
	Butt joints, single strap	...	...	...	·2	·1	...
	,, ,, double strap	...	...	...	·1	...	...
Strakes not entirely over or under		...	·25	...	...	...	...
Long boilers or flues		...	·3	...	...	...	...
Seams improperly crossed		...	·4	...	...	...	...
Doubtful material		...	·4	...	...	...	...
Not inspected during construction		...	1·65	...	...	...	...

In the first place, what is the strength of the material at our disposal?

From the shell plates test-strips have been cut, which show, unannealed, a tensile strength of 27·9 tons per sq. in. of section; or, say, 62,500 lbs.; with an elongation, taken on a length of 10 ins. of 26 per cent., and a contraction of area of 47 per cent. at the point of fracture. Firebox plates 25½ tons, or, say, 57,000 lbs.: 28 per cent. elongation, and 48 per cent. contraction. Both samples have stood without cracking being heated to a cherry red, plunged into water at 80 degs. Fahr., and then being doubled over flat when cold. A strip of either plate 3 ins. wide, having a ⅝-in. hole drilled through it, will stand a drifting test of driving through the hole a taper punch until it is enlarged to 1⅛-in. cold, without cracking.

The steel rivets employed show a tenacity of 26 tons, or, say, 58,250 lbs. per sq. in. of section, elongation 31 per cent., contraction 66 per cent. They will double over cold upon themselves, and will stand the head being flattened out, hot, to ⅛-in. thickness without fraying or cracking. The steel stays, which must not be welded or worked in the fire, are of the same material as the shell plates.

We have not space in the present article to discuss the character of the riveted joints. For the moment we may assume that the double-riveted, double butt-strapped, longitudinal seams in the barrel (Fig. 5) possess a strength equal to 78 per cent. of the solid plate; and the single-riveted, lap-jointed, circular and cross seams a strength of 56 per cent. of the solid plate. We have here the data from which we may, by a little reasoning, determine the scantlings of every part of the boiler.

First we will deal with the strength of the cylindrical barrel, of which, being composed of two rings of plates disposed telescopically, the mean diameter is, say, 51 ins. What should be the thickness of the plate?

The pressure within the boiler acts radially and equally all round, tending to stretch the plate, first into the form of a true circle, and then to enlarge this circle diametrically to the limit of the material's elasticity, or, until rupture occurs, at some point in the circumference where the strength is reduced—usually through a line of rivet-holes, taking the line of least resistance. What is the force tending to rupture the plate at any one point, say *B*, in the diagram? (Page 421.)

Clearly, it is a force at right angles to *A B*. Consider a short section of the

barrel, for convenience say 1 in. in length.

It hardly needs to be proved here that the force acting in the direction of the arrow at any radius, as O 2, is resolvable into two forces: one, which does not concern us now, acting along O B, and measured by O b, the other acting at right angles to it and measured by b 2. Now imagine the diagram drawn full size for a 51-in. circle with all the 80 radii (corresponding to the number of 1-in. spaces into which the semi-circumference may be conceived to be divided), we should get the total of all the resolved forces acting at right angles to A B by adding the lengths of all the sines like a 1 and b 2; and we know, or can ascertain by trial, that the average length of all the sines in a semicircle approximates to ·6366 times the radius. The more numerous the sines are the nearer this value becomes correct. Hence the total stress tending to fracture the 1-in. hoop, or section of the barrel at the two points, A and B, is ·6366 × 80 times the pressure per sq. in. But ·6366 times the semi-circumference equals the diameter, so we come to the simple formula of $p \times d$, or, pressure × diameter. Half this, or, pressure × radius, has to be resisted by the metal at any *one* point in the circumference, hence in our formula we use the radius instead of the diameter. Thus:—

Let P be the intended working pressure.
F the factor of safety.
r the mean radius of barrel in inches.
f the strength of longitudinal rivet-seam (the solid plate being 1).
S the tensile strength of the material in pounds.
T the thickness of plate in inches.

Then,

$$\frac{P \times F \times r}{f \times S} = T \qquad (1.)$$

Substituting the values in the present case, we have

$$\frac{150 \times 5{\cdot}2 \times 25{\cdot}5}{{\cdot}78 \times 62{,}500} = {\cdot}41 \text{ in., or say } \tfrac{13}{32} \text{ in.}$$

In practice we should probably make this $\frac{7}{16}$-in., which would give a factor of safety of $5\frac{1}{2}$ for this joint.

Now, our 51-in. barrel, ·41 ins. thick, has a circumference of 160·1 ins., and an area of 2,042·8 sq. ins., assumed subject to 150 × 5·2 = 780 lbs. pressure per sq. in. What must be the strength of the circular seams to be of equal strength with the 78 per cent. longitudinal seam? —the solid plate being 1.

$$\frac{2{,}042{\cdot}8 \times 780}{160{\cdot}1 \times {\cdot}41 \times 62{,}500} = {\cdot}39$$

or, exactly one half. Hence our 56 per cent. single-riveted circular seam is more than strong enough. For in the circular seams a single-riveted joint whose strength is anything over 50 per cent. would be as strong as the solid plate is longitudinally.

The riveting round the foundation ring —the solid wrought iron or steel bar which unites the inner and outer fire-boxes —must be considered as carrying the whole of the downward pressure due to the internal area of the fire-box shell. We take no account of the support afforded by the resistance to bending of the numerous screwed stays round the sides of the fire-box, nor of the holding power of the solid ring round the fire-hole. The value of these, whatever it may be, is so much to the good. Our principle must be that every known stress must be resisted by a specific and ascertained means.

The inside measurement of the fire-box shell is $51\frac{1}{8}$ ins. each way, which, allowing for the rounded corners, gives a net area of 2,605 sq. ins. subjected to a downward pressure of 150 lbs. per sq. in., or a total of 390,750 lbs. What have we to resist this considerable stress? Only an estimated value for the riveting round the foundation ring of 56 per cent. of the material in the inside fire-box plates—78·31 sq. ins. in horizontal sectional area of steel at 57,000 lbs. tensile strength. 56 per cent. of this, divided by the total downward pressure, gives a factor of safety of nearly 6·4, which is quite satisfactory.

We must now turn our attention to the strength and staying of the flat surfaces of the boiler. This is a matter which does not lend itself to such ready calculation

from first principles, all that we can do being to frame the problem and turn for its solution to some competent authority, in whose deductions from data afforded by actual tests under the given conditions we are prepared to place confidence.

Let us examine the conditions. The possible causes of failure in the artificially strengthened flat surfaces of a steam boiler exposed to bulging pressure may be classified thus :—

(*a*) The bulging or cracking of the plate between the stays.
(*b*) The breakage of the stays themselves.
(*c*) The stripping of the heads and slipping of the threads of screwed-in-and-riveted stays owing to the stretching of the plate at the stay-holes.

Regarding (*a*) we see at a glance that it is a question of (1) the tensile strength of the material, (2) the thickness of the plate, and (3) the situation of the plate—whether exposed to the action of the fire or not, and with or without water in contact; (*b*) is a simple question of tensile strength and sectional area; and (*c*) is again dependent very much upon the conditions of (*a*) as well as upon the method of fixing the stays in the plate.

It is quite evident that the usual cut-and-dried formula for the pitch of screwed stays,

$$\sqrt{\frac{A \times S}{P \times F}} = H$$

where H is the required pitch of the stays, and A the sectional area of the stay at bottom of thread—which takes no account even of the thickness of the plate to be stayed—is of no real value. It is merely an inversion of the formula for finding the sectional area, A, of the stay, when the pitch, H, has been settled by other considerations, as,

$$\frac{H^2 \times P \times F}{S} = A \qquad (11.)$$

For the determination of the pitch H, where H^2 represents the safe unsupported area of plate under different circumstances, we must introduce a factor in the shape of a constant from the subjoined table, which embodies the results of experiments undertaken at public expense by the Board of Trade.

Let t be the thickness of plate in sixteenths of an inch.
Let C be the applicable constant from the table according to the method of fastening employed, and the situation of the plate.

CONSTANTS.	WATER IN CONTACT WITH THE PLATES.		STEAM IN CONTACT WITH THE PLATES.	
For the Staying of Flat Surfaces. From the Board of Trade's Rules. CONDITIONS.	If Exposed to the Impact of Heat or Flame.	Not Exposed to the Impact of Heat or Flame.	If Exposed to the Impact of Heat or Flame.	Not Exposed to the Impact of Heat or Flame.
Stays fitted with nuts and strips riveted on outside, of at least the thickness of the plates they cover, and width not less than $\frac{3}{4}$ the pitch of the stays	...	200	...	...
Stays fitted with nuts and washers riveted on outside of at least the thickness of the plates they cover, and diameter not less than $\frac{3}{4}$ the pitch of the stays.	...	187½	..	...
Stays fitted with nuts and washers at least three times the diameter of the stays and $\frac{1}{8}$ the thickness of the plates they cover.	...	125	75	..
Stays screwed into the plate and fitted with nuts.	100	...	...	...
Stays fitted with nuts only...	...	112½	67½	...
Stays screwed into the plate and riveted over to form substantial heads.	66	75	...	...

Then P, the working pressure, may be

$$\frac{C \times (t+1)^2}{H^2 - 6} = P \qquad \text{(III.)}$$

—and from this, by inversion we may find the pitch H, when the other factors are fixed.

$$\sqrt{\frac{C \times (t+1)^2 + 6}{P}} = H \qquad \text{(IV.)}$$

For the side stays in the firebox we take the constant 66 from the table, and with $\frac{7}{16}$-in. plate we have for the pitch—

$$\sqrt{\frac{66 \times 64}{150} + 6} = \sqrt{34{\cdot}2} = \text{say } 5\tfrac{3}{4} \text{ ins.}$$

as the nearest convenient dimension.

In Fig. 2 it will be seen that the top row of stays occurs at the level of the centre line of the boiler, and it should never be lower than this. From this, measured vertically downwards to the centre of the rivet-holes in the foundation ring, is $52\frac{3}{4}$ ins., so that we get nine rows of stays vertically at say $5\frac{7}{8}$ ins. pitch.

In Fig. 3 we can measure from the half-section that the extreme distance between centres of rivet-holes is $42\frac{3}{4}$ ins., so that horizontally we get in seven rows at a pitch of $\frac{42{\cdot}75}{8}$ = say $5\frac{3}{8}$ ins. Each of these stays, therefore, will be supporting an area of $5\frac{7}{8}$ ins. × $5\frac{3}{8}$ ins. say $31\frac{1}{2}$ sq. ins., which is well within the 34·2 indicated by the formula.

Again in Fig. 3 we can measure the length of the actual flat surface between the centres of the rounded corners of the back and front plates of the firebox shell in plan, as 44 ins.; and we get in seven rows at $\frac{44}{8}$ = say $5\frac{1}{2}$ ins. pitch, giving an area of $5\frac{7}{8}$ ins. × $5\frac{1}{2}$ ins. = say $32\frac{3}{8}$ sq. ins. supported by each stay.

The material of the stays (being steel of the quality already specified), if we adopt the constants in the table, must not be stressed to more than 9,000 lbs. per square inch of section; and the stays must uot be welded or worked in the fire. Taking the $32\frac{3}{8}$ sq. ins. area of plate, and the 150 lbs. working pressure, we have

$$\frac{32{\cdot}375}{9{,}000} = {\cdot}54$$

as the required area at bottom of thread.

The subjoined table of Whitworth screw-threads will show that the nearest standard screw is the one-inch, which has an area at bottom of thread of ·5541, with 8 threads to the inch :—

TABLE OF WHITWORTH SCREW THREADS.

Diam. of Screw ...	$\frac{3}{4}$	$\frac{7}{8}$	1 in.	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2 in.
Threads per inch ...	10	9	8	7	7	6	6	5	5	$4\frac{1}{2}$	$4\frac{1}{2}$
Area at bottom ...	·3038	·4208	·5541	·6969	·8941	1·058	1·298	1·471	1·753	1·985	2·51

We have now to provide for staying the crown-plate or roof of the inner firebox. Figs. 1 and 2 show the usual form of roof-girder, by which the whole pressure upon the firebox crown is collected and transmitted to the vertical end-plates of the firebox. We have here an actual flat surface of $42\frac{1}{2}$ ins. long (Fig. 1) by 36 ins. wide (Fig. 2), measured in each case between the centres from which the rounded corners are struck. Following the method just used for the sides of the firebox, but adopting the constant 100 from the staying table, instead of 66, because the bolts screwed through the plate will be fitted with nuts, we have as the maximum pitch of the stays by Formula IV.,

$$\sqrt{\frac{100 \times 64}{150} + 6} = \sqrt{48{\cdot}6} = 7 \text{ ins.}$$

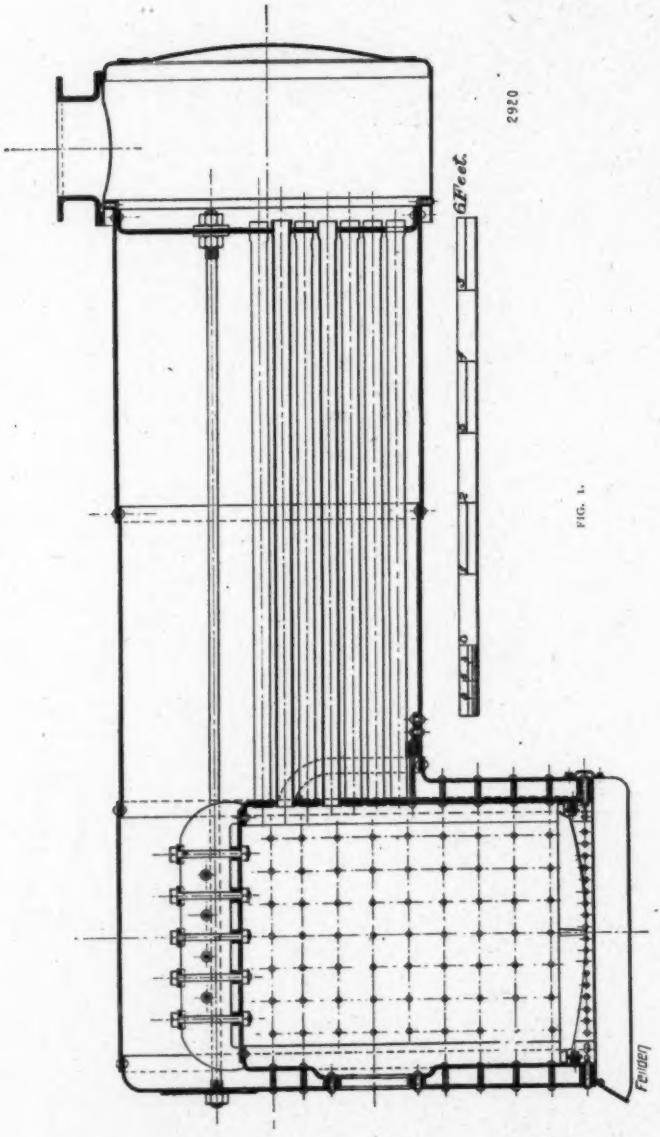


FIG. 1.

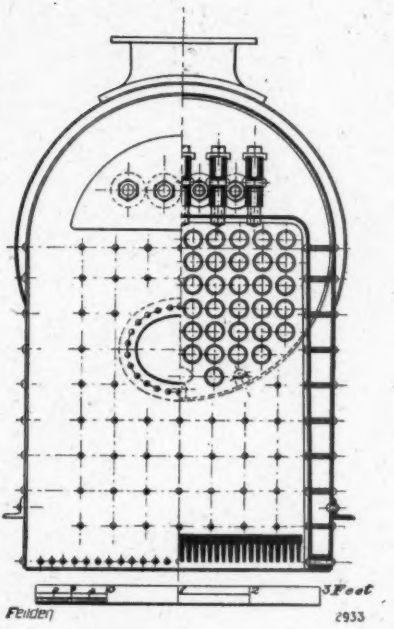


FIG. 2.

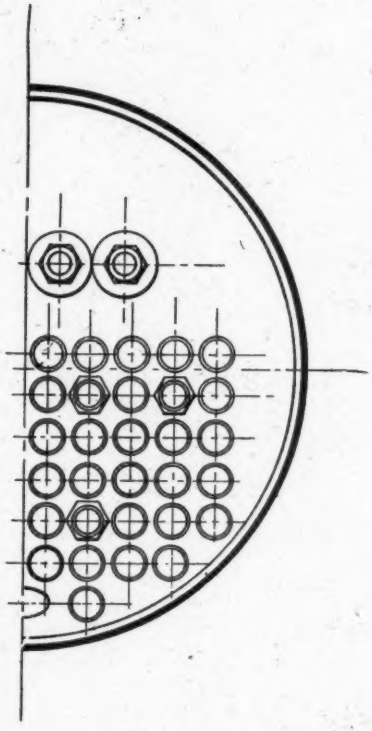


FIG. 4.

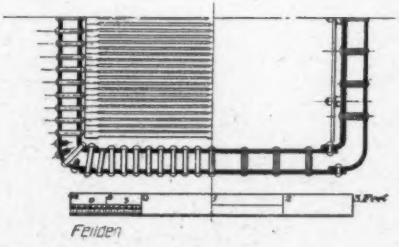


FIG. 3.

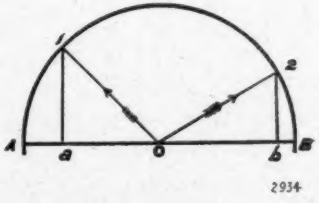


DIAGRAM OF FORCES TENDING TO RUPTURE A PLATE.

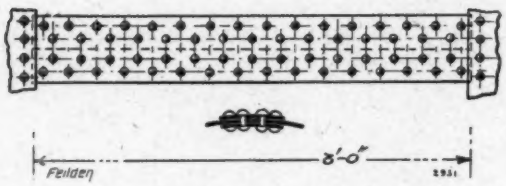


FIG. 5.

As this comes a little outside the permissible stress upon the nearest suitable size of stay-bolt, we must reduce the pitch a little. An $1\frac{1}{8}$ in. Whitworth thread (see the table of screw-threads) has an effective sectional area of ·6969 sq. ins. Hence at 9,000 lbs. stress we have, as the maximum area which this size bolt should support, $\frac{\cdot6969 \times 9000}{150} =$ say 42 sq. ins., which we may take as 7 in. pitch one way and 6 in. the other. If we have five girders at $\frac{36}{6} = 6$ ins. apart, with five bolts in each at $\frac{42\cdot5}{6} =$ say 7 in. pitch, an $1\frac{1}{8}$ in. bolt will just be right.

Now, as previously mentioned, the whole pressure upon the firebox crown is in effect sustained by the vertical end plates of the firebox. One of them, the back or firehole plate, is well able to support the load thus thrown upon it; but the front, or tube-plate, is seriously weakened, or robbed of its sectional area, by the holes cut in it for the tubes, and must therefore be made thick enough to resist crushing or crumpling under the considerable stress thrown upon it.

If we take a strip of the firebox crown half its length (inside measurement) and of a width equal to one tube-pitch (*i.e.*, the distance horizontally between the centres of the tubes), and multiply the area thus found by the working pressure, we shall have the load to be carried by a like width of the tube-plate, minus, of course, the inside diameter of one tube. As the stress is limited to 10,000 lbs. per square inch of sectional area we find the necessary thickness for the tube-plate by the following formula, which embodies the above reasoning. Thus: let T be the required thickness of the tube-plate; D, the inside diameter of the tube in inches; E, the horizontal pitch of the tubes; and B, half the inside length of the firebox in inches.

Then:

$$\frac{B \times E \times P}{10{,}000 \times (E - D)} = T \qquad \text{(V.)}$$

or in this case

$$\frac{22 \times 3\cdot875 \times 150}{10{,}000 \times (3\cdot875 - 2\cdot5)} = \cdot93 \text{ in.}$$

It is hardly necessary to point out that in practice a tube-plate of this thickness would always give trouble by becoming overheated, and the tubes in consequence would be incessantly leaking where they

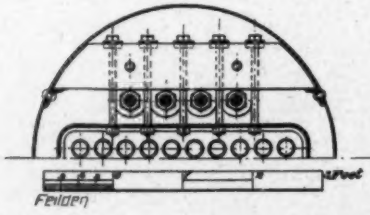


FIG. 6.

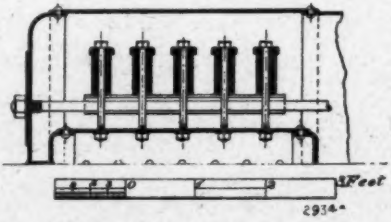


FIG. 7.

were fixed into the tube-plate. Very much thinner tube-plates are used in loco-type boilers, and a 12,000 lbs. stress may without fear be substituted in Formula V. for the Board's 10,000, giving a thickness in the present case of ·77 ins., or say $\frac{3}{4}$ in. By adopting another method of staying the crown-plate, whereby the tube-plate is relieved of this crushing stress, its thickness might be reduced to $\frac{5}{8}$ in., or even $\frac{9}{16}$ in., with advantage to the durability and efficiency of the firebox. This we shall discuss later.

The smokebox tube-plate enjoys a much more favourable situation; it is not liable to overheating from being too thick, nor to crushing from being too thin; and we may safely put it down at $\frac{11}{16}$ in. thick.

We have next to consider the staying of the two tube-plates by making a certain proportion of the total number of tubes into screw stay-tubes. The Board of Trade do not admit that the ordinary tubes, expanded into the tube-plates and beaded over at the firebox end, possess any holding power at all; and require, in boilers built under their rules, that the tube-plates be fully stayed by screw-tubes. This is a wise provision, though seldom acted upon to the full extent called for by the Board; for though the holding power of newly-expanded tubes is enormous, yet it must be remembered that they are liable to become slack if overheated.

It is probable that the following method of finding the number of screw-tubes would not meet with the approval of the Board of Trade, but experience has shown that for loco-type boilers it provides ample security in practice.

As our tubes are pitched at $3\frac{7}{8}$ in. centres, each tube represents a tube-plate surface of $3\frac{7}{8}$ in. $\times$ $3\frac{7}{8}$ in., less the area of a $2\frac{3}{4}$ in. circle, or nine square inches. There being 60 tubes, we have 540 sq. ins. to stay.

Using Formula IV. again, with the applicable constant 66 from the staying table, we have

$$\sqrt{\frac{66 \times 160}{150} + 6} = \sqrt{80{\cdot}3} = \text{say } 9 \text{ ins.}$$

as the pitch of the screw-tubes, and $\frac{540}{9^2} = 7$ as the nearest whole number of screw-tubes.

The minimum thickness allowed is $\frac{1}{4}$ in., and the maximum stress per square inch of sectional area is 7500 lbs. for steel tubes. There will therefore have to be $\frac{81 \times 150}{7500} = 1{\cdot}6$ sq. ins. of material in

FIG. 8.

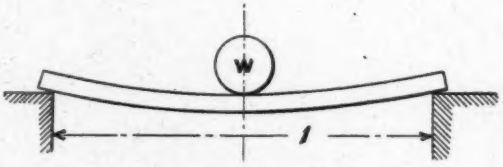


FIG. 9.

FIG. 10.

cross-section, which just corresponds to a tube $2\frac{7}{8}$ in. diameter externally and $2\frac{1}{2}$ in. bore. These tubes are screwed in by means of a six-sided head formed on them at the smoke-box end, and are expanded and beaded over like the plain tubes at the firebox end.

In the smokebox tube-plate we are entitled to a pitch of 11·22 ins. by Formula

IV., using the applicable constant 125 from the staying table. The dotted segmental area shown in Fig. 4 represents the area to be stayed by the longitudinal stay rods, the arc being described at half-a-pitch, or $\frac{11{\cdot}22}{2} = 5{\cdot}6$ ins. from the flange of the circular tube-plate; and the chord at the same distance from the centre of the upper row of screw tubes.

The area of this segment is about 450 square inches, and the number of stay-rods is restricted to four, as they have to pass between the roof girders. What must be the sectional area of these stays, each of them having to carry $\frac{450}{4} = 112\frac{1}{2}$ sq. inches? At 9000 lbs. stress we have

$$\frac{112{\cdot}5 \times 150}{9{,}000} = 1{\cdot}875 \text{ sq. ins.}$$

and turning to the table of Whitworth screw-threads we find that this area comes just within that of the $1\frac{7}{8}$ in. screw, measured, of course, at the bottom of the thread. To give uniform stretching the diameter of the plain part of the stay-rod must be reduced to that of the bottom of the threads, or say 1·6 in. diameter. Note that these steel stays must not be welded or worked in the fire, hence this means, if carried out, that the rods must be turned in the lathe to this diameter in the plain part between the screwed ends.

These longitudinal stays should be placed in a horizontal line passing through the centre of gravity of the segmental figure; which point is most easily found by cutting out in cardboard a similar figure to any scale, and suspending it successively in two or more positions, then the intersection of the vertical lines from each point of suspension will indicate the position of the centre of gravity.

At the smokebox end these rods pass through clear holes in the tube-plate, and are fitted, under the nuts on each side, with washers "at least $\frac{2}{3}$ the thickness of the plates they cover, and not less than three times the diameter of the stay across the thread." At the other end they pass through the outer or shell-plate of the firebox. A segment-shaped plate of equal thickness, $\frac{7}{16}$ in., with the boiler shell, and of the same size as the segmental dotted area in the smokebox tube-plate, is double-riveted all round to the outside of the firebox shell-plate; and the stay-rods are screwed into this double thickness, being fitted with nuts on the outside only. It will be found by measurement that this reinforcing plate approaches within half-a-pitch, or three inches, of the rounded corner of the shell-plate, and to the same distance from the centre line of the top row of firebox screw-stays.

We have now only to consider the method of ascertaining the dimensions of the roof-girders for the firebox. Each of the five girders has five bolts, each one sustaining a load of $42 \times 150 = 6{,}300$ lbs., or 31,500 lbs. in all. Assuming a convenient thickness, say $1\frac{1}{2}$ in. (*i.e.* a pair of $\frac{3}{4}$-in. plates riveted together, with distance-pieces between), we may proceed to calculate the required depth of the girders. But we must first fix upon the permissible stress on the material.

Adhering to our factor of safety of 5·2, we have

$$\frac{S}{F} = \frac{62{,}500}{5{\cdot}2} \text{ or } 12{,}000 \text{ lbs.}$$

as the limit to which we may load the material of the girder per square inch of its section. Considering that the girders are little subject to overheating or corrosion, this would seem an ample allowance. As the Board of Trade, however, will only permit a stress of 9,900 lbs. per square inch for steel; the constants, or values of K for both are given in the following table:—

VALUES OF K FOR FORMULA VI.

No. of bolts	1	2 or 3	4 or 5	6 or 7	8 or 9	10 & up.
Values of K for 12,000 lb. stress	8,000	12,000	13,333	14,000	14,400	16,000
Values of K for 9,900 lb. stress	6,600	9,900	11,000	11,550	11,880	13,200

Now, let W be the total load in pounds upon each girder.
And let l be the span (*i.e.* inside length of firebox, in inches).
And let b be the breadth (*i.e.* total thickness of girder, in inches).
And let d be the required depth of girder, in inches.
And let N be the number of bolts in the girder.
And let K be the constant from the table, applicable to the number of bolts in the girder.
The formula is:

$$\sqrt{\frac{W \times l}{K \times b}} = d \qquad \text{(VI.)}$$

We have thus, for 12,000 lbs. stress in the present case, noting that the span l is $44\frac{1}{4}$ ins.

$$\sqrt{\frac{31{,}500 \times 44{\cdot}25}{13{,}333 \times 1{\cdot}5}} = \sqrt{70} = \text{say } 8\tfrac{1}{4} \text{ ins.}$$

as the depth.

There are several methods by which the pressure of the ends or toes of the girders upon the vertical end plates of the firebox can be relieved or eliminated altogether. For instance, the girders may be slung by links from angle-irons riveted to the underside of the firebox shell. As the firebox crown rises in the boiler during the process of getting up steam through expansion of the material, and then settles down as the steam-pressure comes upon it, provision for this relative movement must be made in the links by slotting the pin-holes; and it is very evident that the difficulty of adjusting the length of these links, so as to take a partial stress of given value, amounts to a practical impossibility.

If these are used at all, there is nothing for it but to proportion them for taking the whole of the load, in which case the girders may almost as well be suppressed altogether, and to let the sling-stays resolve themselves into direct bolts between the inner and outer firebox roofs. Here again a difficulty is met with, owing to the awkward angles at which the bolts penetrate the arch of the firebox shell, if they are placed vertically, or normal to the firebox crown. This difficulty is partially overcome in some cases by making the firebox crown in the form of a very flat arch—losing thereby some inches in the water-level—when the bolts assume a more or less radial position, a compromise between two irreconcilable conditions.

A much better plan is to adopt the well-known Belpaire pattern of square-topped firebox shell, which admits of vertical screw-stays exactly similar to those in the sides of the firebox, though usually fitted with nuts. Needless to remark, this method adds considerably to the weight and cost of the boiler, as the flat sides of the firebox shell, when prolonged upwards in this way, require transverse stay-rods similar to the longitudinal stays, and proportioned by the same rules.

An incidental advantage over the ordinary roof-girder system is possessed by the direct stays in the free access they permit to the whole surface of the crown-plate, which, from its horizontal position, is exceptionally liable to the accumulation of deposit from the water, leading to overheating and sometimes to collapse. Roof-girders are commonly placed within an inch or so of the crown-plate, and this space is generally choked with deposit at an early stage, to the great detriment of the firebox.

These considerations have led to the modification shown in Figs. 6 and 7, which retains the advantages of the direct stays without the use of the flat-topped firebox shell. As will be seen, the girders are placed transversely, and rest upon angle-bars of a special section riveted to the arch of the shell-plate. The objectionable pressure of the girder-ends upon the tube-plate is removed; the upward expansion of the firebox is in no way restrained; and the whole surface of the crown-plate is visible and accessible for cleaning. The girders themselves are shorter, and lighter for equal strength, than those of the old system, and are readily removed and replaced when necessary for repair of the boiler.

This system is the speciality of Messrs. Robey & Co., Ltd., of Lincoln, and has been applied by them to large numbers

of loco-type boilers, of the largest as well as the ordinary sizes, with complete success.

A few words upon the method of calculating the strength of solid girders of rectangular section, as commonly used for firebox crown-stays, may fitly close this paper. Those who, rightly, view with suspicion any formula which does not disclose the method by which it is evolved, may check the results for themselves, if they so please, by observation of the simple principles which determine the stresses upon rectangular beams.

We may take, as an example for illustration, the girder in Fig. 6, shown diagrammatically in Fig. 8. Assuming a certain strength for the material, say 12,000 lbs. per square inch of section in the present case, we have to first find the maximum stress on the girder *A B* under the given conditions, and then to provide a cross-sectional area in the girder, such that at no point shall it be stressed to more than the prescribed amount.

There are five bolts, spaced as shown, each sustaining an area of fire-box crown of 42 sq. ins., loaded with 150 lbs. pressure per sq. in., hence each bolt supports 6,300 lbs.

The total load, which call *W*, amounts, therefore, to 31,500 lbs.; half of which, or 15,750 lbs., rests upon each abutment. As the girder is symmetrically loaded, we need only concern ourselves with one half, or the length *A C*. As *l*, the span, is 42 ins., *A C* is 21 ins. Taking moments round the centre *C*, we have the reaction or upward pressure at *A* (equal to the load) of 15,750 lbs., acting at *C* with a leverage of 21 ins., say, 330,750 in.-lbs.

Against this we have 6,300 lbs. at *E*, a downward pull acting at 6 ins. from *C*, say, 37,800 in.-lbs.; and a further 6,300 lbs. at *D*, acting at 12 ins. from *C*, say, 75,600 in.-lbs.

Subtracting the sum of these, or 113,400 in.-lbs., from the 330,750 of upward pressure, we get the figure of 217,350 in.-lbs., which is the *bending moment* for this particular case; or, in other words, the leverage acting at *C*, the point of maximum stress, tending to break or bend the beam there.

These are the conditions for which we have now to design a girder consisting of two parallel bars of rectangular section, which are not to be stressed to more than 12,000 lbs. per sq. in. of section at any point.

As we have for the moment thrown overboard all formulæ we shall have to reason this out for ourselves, and find the dimensions of a beam whose *moment of resistance* shall equal the bending moment just found.

Now suppose a rectangular beam spanning a gap, with a single load placed on it at the centre of the span. What happens? The beam is stressed and therefore bends, or possibly breaks, the greatest stress occurring at the centre of the span.

Granting that the material, say steel, is approximately of the same strength in tension as in compression, it is obvious that the beam cannot be bent except by a compression of the material near the top, and an extension of that near the bottom. Actual measurement of the respective lengths of the upper and under surfaces of a bent beam, like that in the sketch, Fig. 9, will convince anyone that this is true.

Consider a cross section of the beam, Fig. 10. The compression cannot change into extension without passing through a zero plane, situated in our case at the centre of the beam's depth; and in any cross-section the line indicating this plane is called the neutral axis.

The intensity of the stress varies uniformly as the distance from the neutral axis; and in value is represented by the shaded triangles, which are together just half the area of the total section.

The compressive and tensile stresses may be considered as, respectively, concentrated at the centres of gravity of the upper and lower triangles, denoted by the small black dots in the figure.

If we call the breadth of the beam *b*, and the depth *d*, we have, taking the upper part of the beam only, an area of $\frac{b\,d}{2}$, only half of which, or $\frac{b\,d}{4}$, is actual value (the shaded area). Multiplying the permissible stress on the material (which

is usually denoted by C, as 12,000 lbs. for example) by the effective area, we have $\frac{C\ b\ d}{4}$ as the available resistance. It will be remembered that the bending moment is a load of so many pounds at a leverage of so many inches. Here, also, we have opposed to it a *resistance* of so many pounds, but we must know at what leverage or distance from the neutral axis it acts. It acts, of course, at the centre of gravity of the triangular area, which we know to be situated at a point one-third the triangle's height from the base, which is one-third of the depth d from the neutral axis. This is the leverage of the resistance-area, and we have $\frac{C\ b\ d}{4} \times \frac{d}{3}$ for *each* half of the beam section, which for the whole section becomes $\frac{C\ b\ d^2}{6}$, the usual and well-known expression for the moment of resistance of any solid rectangular beam. This is how the formula is manufactured. Now to make use of it.

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Where the bolts are equally spaced form end to end of the girder, Formula VI., which is a short method of doing the work we have here given at full length, will give identical results. In the present case it will be observed that, though the bolts themselves are at 6 ins. pitch, yet the first and last bolts are each 9 ins. from the ends of the girder. In such cases the bending moment must be calculated for each case, but the moment of resistance is always $\frac{C\ b\ d^2}{6}$ for solid beams of rectangular section.

In conclusion, though opinions may differ as to the exact margin or factor of safety it is wise to allow in these boilers, yet, when every separate part of the boiler is designed with reference to the burden it has to bear, there is good reason to believe that the structure will be of approximately equal strength throughout, and that the designer will will never be called upon to face a Board of Trade enquiry under the "Boiler Explosions Act, 1883."

W. D. Wansbrough.

How Great Britain is meeting Foreign Competition.

Speaking of the restless enterprise of the Americans, Lord Rosebery recently remarked that in the New World the disdain of finality, the anxiety for improving the best, seemed almost a disease: but in Great Britain we could afford to catch the complaint, at any rate, in a mitigated form, and give in exchange some of our own self-complacency. We needed to be inoculated with some of the nervous energy of the Americans.

Whilst endorsing Lord Rosebery's views, and largely sharing the opinions of other critics that our country has too long traded on its unique reputation, FEILDEN'S MAGAZINE deprecates anything which might tend to show that Great Britain is a decadent nation, and is not able to compete, or capable of turning out work equal in price or quality to that of America or any other country. We will go further, and say, in the majority of cases, given the same conditions, we could and can beat them! But nothing must be left to chance. That the unprecedented scale of progress which has been vouchsafed to this country in the past is not going to warp the minds and stultify the actions of our manufacturers is beginning to show itself pretty forcibly in the magnificent equipment of many new workshops throughout the United Kingdom; and whilst we shall continue to impress British firms with the necessity of constantly following the sage advice of Lord Rosebery, we cannot allow it to go forth that we have nothing but obsolete plants and ideas in this country. In a recent issue we started a series of articles, entitled "How Great Britain is Meeting Foreign Competition," and produced a profusely illustrated article written by an expert member of our staff, showing the up-to-date nature and completeness of a great North of England shop. In our next and following issues we shall continue the series. Many of our manufacturers will do well, in their own and the country's interests, to take a leaf out of the book of the firms under review. The details should form object lessons of great value.

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Electrical Machinery at the Glasgow International Exhibition.

By SYDNEY F. WALKER, A.M.Inst.C.E., M.I.Mech.E., M.I.E.E.

III.—THE BRITISH SCHUCKERT COMPANY.

The British Schuckert Company have one of the most complete electrical exhibits in the whole show. They have a large stall in the Machinery Hall, also a pavilion in the grounds, while attached to this pavilion is a short track on which electric locomotives run, one taking its current from an overhead trolley wire, and the other supplied by accumulators. By the side of the locomotive track also are the delivery pipe of the large pump, that is driven by an electric motor in the pavilion, and the carriage of an electric tram, without the superstructure, so that all the details of the motor and its connections can be seen.

The accumulator locomotive carries a battery of 39 cells, each of 7 plates—3 negatives and 4 positives. The cells are of vulcanite, 9½ ins. by 5 ins. by 14½ ins. deep outside all, the plates being 12 ins. deep. The plates are separated by ⅜-in. glass tubes, and the positive plates are hung on ½-in. glass tubes, supported on the negative plates. There is a space at the bottom of the cells of about 1 in. The current delivered by the cells is stated to be 63 amps. for one hour, or, as usual in these cases, a larger total discharge, if it is taken out at a lower rate. The particular locomotive exhibited is stated to have been working in the Bomfazins Mine, in Westphalia, for two years. The batteries looked in very good condition. The locomotive carriage consists of a light frame of channel steel, suspended over the axles by four spiral springs. There are two motors, one on each axle, each geared to its axle by spur gearing—1 to 5—the motors being enclosed. The driver sits at one end on a stool by the side of the controlling switch, and he has a mechanical brake, with a counterbalance weight. The battery is stated to require three hours to charge when fully discharged.

The trolley locomotive, which is also intended for mining work, is very similar to the accumulator locomotive, but the driver sits in the centre, so that the locomotive can run in either direction, the controller reversing switch and brake being close to his hand. Both locomotives carry headlights, fed by the same current as the motors. The trolley is of peculiar construction. Instead of being of the usual fishing-rod pattern, with a wheel on the end, it consists of two arms, stretching out above the carriage, connected at the top ends by a rod; and on this rod an aluminium roller runs, its periphery pressing against the overhead conductor. The roller is kept pressed against the conductor by springs acting on the arms which support it. In both forms of locomotive the resistances are arranged to be well out of the way, and at the same time to obtain the maximum quantity of cooling from the surrounding atmosphere as the locomotive travels. They are carried in the horns of the locomotive, and consist of wires coiled on porcelain insulators.

The tramway truck is of the pattern that has been fitted by the Schuckert Company in many towns on the Continent. An electric crane is also shown in the ground adjoining the locomotive track, of the Company's usual manufacture.

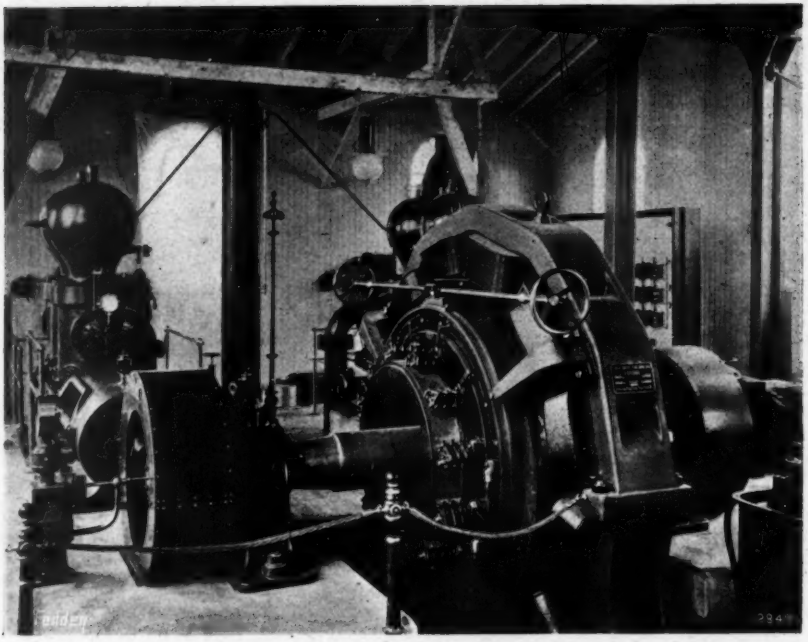
IN THE PAVILION.

The most striking feature in the Schuckert pavilion is the large double-acting plunger pump, driven by a twelve-pole continuous-current motor, designed to work at 500 volts and to absorb

970 amps. The water forced up by the pump forms a fountain on the outside, the water being allowed to fall into a basin, and being forced up again.

The next interesting exhibit is the switchboard, which is of marble, built up on a steel frame in the now well-known manner, and on which is shown the apparatus for breaking a 10,000-volt alternate-current circuit, while it is furnishing current to the extent of 100 h.p. The 10,000-volt pressure is obtained by a series of transformations, which are very interesting, and which again illustrate the flexibility of the electric supply service. In front of the switchboard is a continuous-current motor, taking current from the town supply service at 500 volts, directly coupled to a three-phase generator, which furnishes current at 500 volts, alternate three phase, the output of the combination being 100 kilowatts. The current from the three-phase generator is taken to a three-phase transformer, where it is converted to 10,000 volts, the current from which is turned into a water-tank, but is led through a special switch and automatic cut-out. The apparatus consists of two sets of movable contact pieces, connected in parallel with each other, each engaging with fixed contact pieces, but in such a manner that one set of contacts are open — they are both double-break—before the other; and the second set, those between which the final break occurs, are enclosed between two iron plates, forming a sector of a cylinder. The switch can be worked by a handle or by an electro-magnet. In either case, in making circuit, the contact enclosed between the iron plates is made first, and that the lower ones—the main—contacts after. In breaking circuit the lower contacts are opened first, and then those between the iron plates; and the spark passing between these upper contacts is blown out upwards in a very beautiful manner by the magnetic field formed between the iron plates. The apparatus is known as the Muller Lux system.

THE BRITISH SCHUCKERT CO.: ELECTRICAL HAULING ENGINE.



THE BRITISH SCHUCKERT CO.: PUMP DRIVEN BY 12-POLE CONTINUOUS CURRENT MOTOR.

There is very little electrical mining plant shown in the Exhibition, and, in fact, very little plant connected with mining at all. The British Schuckert Co. have probably the largest and best exhibit in this line. Among other apparatus is a fine specimen of a main and tail electrical haulage plant. The two drums are 2 ft. in diameter each, with 1 ft. depth for the rope. The plant is driven by seven-h.p. motor, placed vertically, and connected mechanically with the drums by double reduction spur gearing, with a flexible clutch between the first and second motion-shafts. The motor runs at 1,160 revolutions per minute, and the plant is capable of winding up 160 yds. of rope at a speed of two miles per hour. The controlling and brake arrangements are very ingenious. The controller is of the usual barrel type, but is worked by a lever similar to the usual steam-engine lever. The property possessed by an electric motor of acting as a brake by generating current when the load is running away is made use of here, and, in addition, an automatic arrangement is provided worked by a chain from the second motion-shaft, which puts the brake on automatically when the load arrives at a certain point.

The firm also show two forms of rock drills for mining work, one form, intended for hard stone, fitted with a crown of diamond cutters, the forward motion of the drill being accomplished by hydraulic pressure; and the other for soft stone, the drill in this case being worked by a flexible shaft from an enclosed motor placed on the ground, the parts of the motor being made in aluminium, except those that must be in iron or steel.

Two forms of drilling machines are also shown, each fitted with a motor carried on an extension of the arm carrying the drill gear, the whole making a very handy and complete apparatus. One is a plain

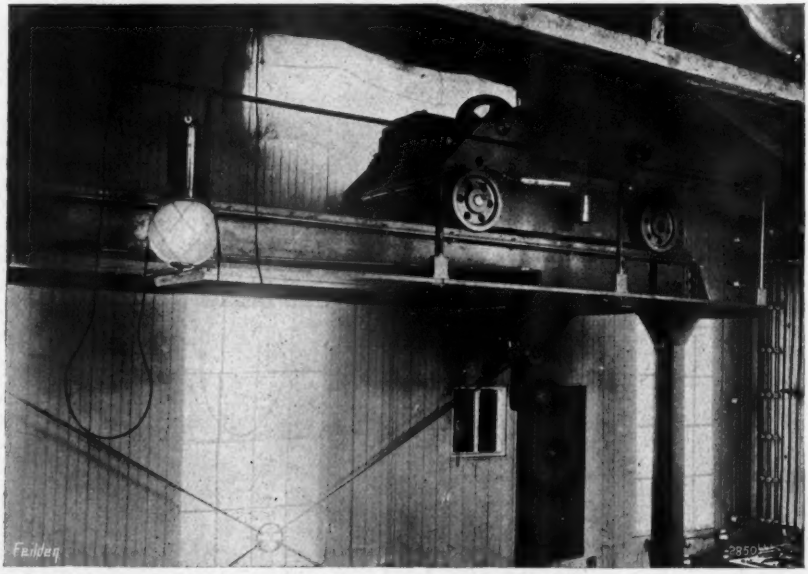
drilling and tapping machine, the other a radial drill. One feature to be noticed about these electric machine tools is the fact that they are all neatly wired, the wires being enclosed in lined brass tubes sufficiently flexible to bend nicely round the curves of the machine, and so to be kept out of the way and fairly out of sight.

THE ELECTRIC SEARCH-LIGHT.

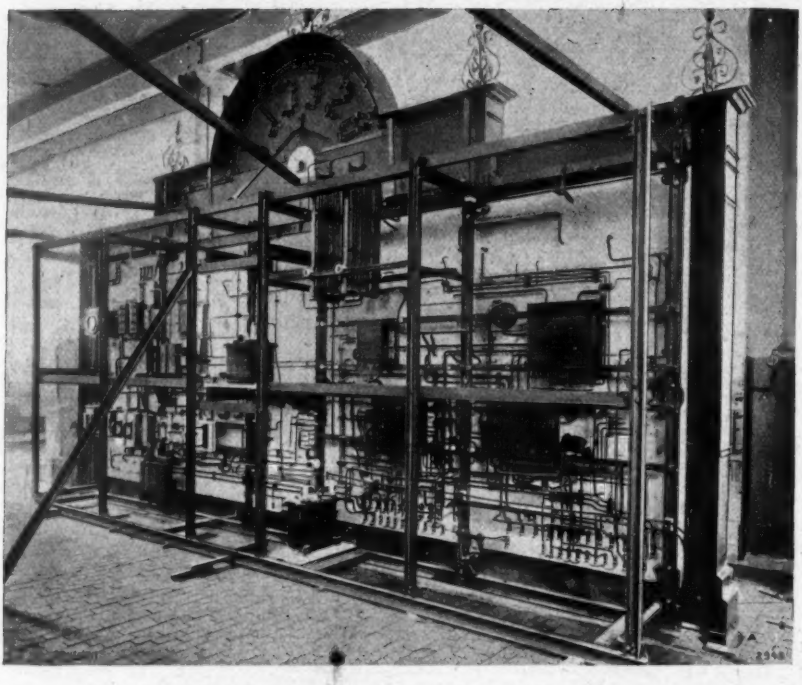
The British Schuckert Electric Search-Light was an important feature in the programme every evening, though during the months of May, June and July it was difficult to find any time when it was dark enough to show it off properly. Even in the dusk, however, its beam, moving about over various portions of the buildings and the grounds, attracted considerable attention. The search-light apparatus was placed on a tower 40 ft. high, on the upper side of the river Kelvin, in the neighbourhood of the University, and the apparatus which supplied the current was placed in the basement. This was composed of a continuous-current rotary converter, consisting of a motor taking current from the Corporation supply service at 500 volts, directly connected mechanically to a generator furnishing current at 110 volts. The current taken from the supply mains at 500 volts was 42 ampères; that supplied to the search-light was 150 ampères. A large resistance, consisting of coils of the Schuckert pattern, carried on porcelain insulators inside a perforated metal chamber, was in circuit with the arc. The lamp is very much the same as that exhibited by Messrs. Clarke, Chapman, without the electrical controlling gear.

THE EXHIBIT IN THE MACHINERY HALL.

The large dynamo, directly connected to the Willans engine in the generating station, has already been alluded to. One remark may be made on this *en passant*. In all these large multipolar dynamos, a portion of the machine is sunk in a pit below the level of the floor, while a portion is above the reach of the



THE BRITISH SCHUCKERT CO.: ELECTRIC CRANE.



THE BRITISH SCHUCKERT CO.: BACK VIEW OF SWITCHBOARD.

attendant, also standing on the floor level. With the Schuckert Co.'s machine alone is any provision made to assist the attendant in getting about the machine. In the pit are steps on each side for him to walk down, whereas he has to jump down with the others; and in front of the commutator are protecting nettings, and steps by which he can get to the higher parts of the machine without danger. This appears to the writer to emphasise one of the points the Institute of Electrical Engineers noticed on their recent visit to Germany —the thought given to the comfort of the workmen.

At the stall of the British Schuckert Co. in the Machinery Hall was a very interesting historical section, in which were shown Herr Schuckert's first dynamo, with the flat disc, which was supposed to be an improvement on the Gramme ring, made in 1886; and the plating machine made by Schuckert in 1878, with the latest type of machine made by the firm of the same output standing alongside; also the Schuckert lamp of 1879, the motor lamp of 1880, and the first Pilsen lamp of 1881. Near the shelf on which these stand is a shelf of electricity meters, of various patterns, all made by the firm, and arranged for different work—continuous current, alternate current supply, &c. A complete system of transmission at 10,000 volts is also shown, the current being taken at 500 volts from the town service, and converted, transmitted across the stall to the switch-board, and there reconverted and distributed to motors about the stand, driving different apparatus. The current is transformed up and down among the various apparatus, from the 10,000 volts alternate to 4 volts continuous, in a manner which thoroughly illustrates the flexibility of the electric current. A series

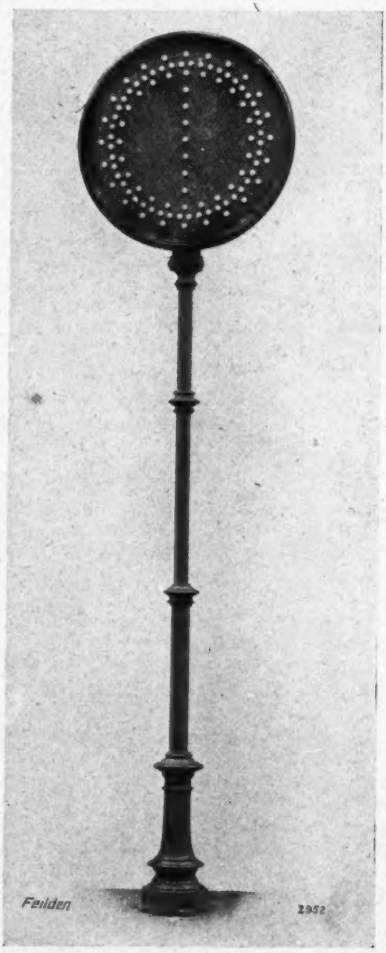
of motors are shown, in which a second motion shaft is carried on top of the motor case, with the first set of gearing by the side all geared one to five, so that a purchaser has only to take the speed of the second motion shaft into his calculations, say 200 revolutions instead of 1,000.

The exhibit of arc lamps is very prettily arranged; the lamps are suspended from a cross-bar supported by two ornamental iron pillars, the arrangement for coupling the arc lamps to their connecting cables without bringing the leads down, while allowing the lamp to be lowered, is a thing that might be usefully copied in this country. Another ingenious and practical apparatus is the firm's arrangement for controlling the number of cells of a secondary battery that are in circuit, automatically. A small relay, whose tongue works between two contacts, between which there is only a few volts' difference in pressure, is so arranged that the attraction to one contact means that more pressure is required, while the attraction to the other means that less is required, is worked by the supply service itself. When contact is made by the relay, a motor is put in operation, which moves contact plates up or down, putting in or taking out cells as required, and it is also arranged that the actual break of contact, when an additional cell is put in, is not made at the contact plates, but at other contacts, which can easily be got at and renewed.

One of the most striking things in the stall, however, is the synchroniser, which at night may be seen in operation, or at least the lamps may be seen lighting up and going out, as if the operation of synchronisation were going on. The apparatus consists of a black disc, about 5 ft. in diameter, upon which are mounted over 100 incandescent lamps connected up in various groups. There are two concentric circles of lamps around the edge of the disc, and one set crossing the disc forming one diameter. As the machines to be synchronised are being brought together, the lamps light up in succession round the disc, the central string taking part occasionally. When the lamps on the right and left, and those in the centre, are alight together, the machines are in synchronism. Inside the disc are circular, three-phase transformers. The disc is carried on a pillar at a height of 20 ft., so that both engine man and switchboard attendant can see it from a distance.

THE ELECTRIC CO.'S EXHIBIT.

This is another remarkably good exhibit. They have a very interesting series

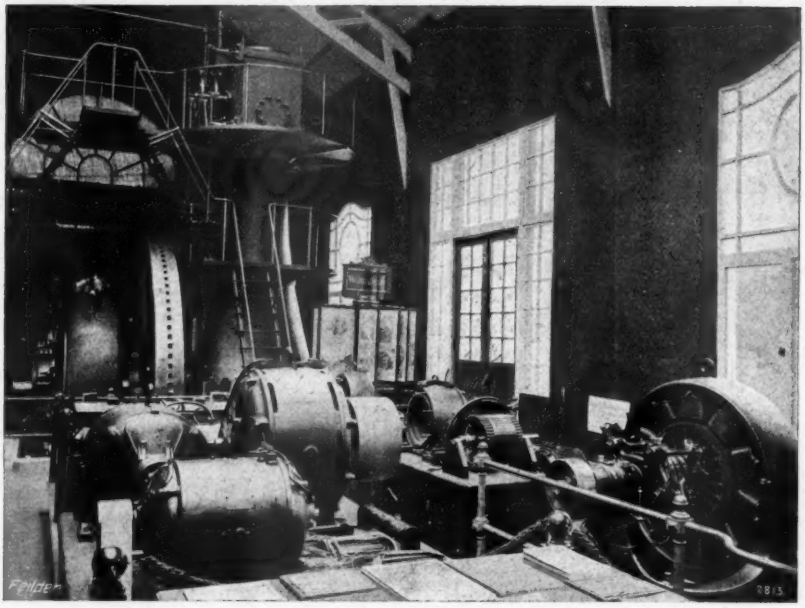


THE BRITISH SCHUCKERT CO.: SYNCHRONISER.

of machines arranged on ornamental iron brackets around the stall, consisting of various sizes of induction motors, from $\frac{1}{8}$ h.p. up to 5 h.p., some of them fitted with mechanical reduction gear; continuous current motors, enclosed, semi-enclosed and open, $7\frac{1}{2}$ up to 30 h.p.; three-phase plant; drilling machines, driven by electric motors from $\frac{1}{2}$ man-power up to $\frac{1}{2}$ h.p., and from pin-drills up to $1\frac{1}{2}$ in., three-phase and direct-current portable drilling machines with flexible shafts, portable stands, and with various forms of drill heads that can be arranged in any position, also electric breast drills, knife switches of all sizes and types, single way, two way, single and double pole, ordinary and quick break, automatic cut-outs, for maximum and minimum current, ampère metres and volt metres and direct-current machines from 2 h.p. up to 54 h.p. In addition they show cases of samples of cables of all kinds for electrical work, beautifully got up, including some high-tension three-phase cable for 10,000 volts, taken from an installation at Rheinfelden, in Switzerland. They also show a case with the parts of the Nernst lamp, and some lamps that they are intending to show, in use. The arrangement of the parts of the Nernst lamp is very interesting, and illustrates very clearly not only the apparatus itself, but the difficulties in the way of its general adoption. The samples of Nernst lamps shown are for 25, 40, 65, and 135 candle-power, all to work with current at 250 volts. All have the straight filament or glower, as it is termed, of rare earths, with the coil of platinum wire around it, and the little electro-magnet at the side to cut out the coil when the filament is heated up. The lamps are stated to work with an efficiency of 1·5 watts per candle. The Electric Co., like the Schuckert Co., have their little illustration of the flexibility of the current. They show a rotary transformer taking current from the town supply at 500 volts continuous, and delivering it at 215 volts three-phase, the three-phase current being then taken to induction motors, one of $7\frac{1}{2}$ h.p., which in its turn drives a continuous-current dynamo furnishing current at 100 volts, and a 10-h.p. motor which drives another continuous-current dynamo delivering current at 200 volts. Samples of the Company's high-tension switches for three-phase working are shown, the three phases being separated by glass, and special forms of corrugated porcelain insulators being used. The switches are stated to have been used with currents up to 15,000 volts. Perhaps the most important exhibits in this Company's stall are the electric ship and steering telegraphs, and the automatic regulator for accumulators for use in electric light and power stations. The accumulator regulator is something on the lines of that described for the Schuckert Company. A solenoid electro-magnet takes current from the bus bars, and works a contact lever between two points, the two contacts being in connection with two electro-magnets between which an iron disc revolves, the disc being driven by a strap from any convenient shaft. When the relay makes contact on either side, the disc armature is pulled to one electro-magnet or the other, and in so doing makes frictional mechanical connection with one of two pairs of coned surfaces, the cones driving spindles which work a contact arm over a contact plate mounted on marble. The same arrangement can be used for varying the resistance in the field-magnet circuits of alternators.

THE SHIP AND STEERING TELEGRAPHS.

Very numerous attempts have been made to solve this very difficult problem, or rather the two problems, to signal to the engine-room from the bridge or conning-tower, and to receive a reply from the engine-room when the order has been obeyed, and to signal to the steering house the steering directions, and to receive an automatic report that the order has been carried out. So far, however, all attempts have been failures. In the apparatus shown by the Electric Co., two new departures have been made which go far to account for its success. The current which is used to work the apparatus is always on, the steel magnet upon which depends the actual movement being held in tension by the action of the current, so that a trifling addition or subtraction of



THE BRITISH WESTINGHOUSE CO.: A VIEW IN THE PAVILION.

the current strength causes motion. The apparatus has all the appearance of the usual bridge telegraph. Inside the circular brass case, under the glass front, are six electro-magnets, arranged in a circle like those of a multipolar dynamo, with a copper cylinder in the centre, inside which are two steel armatures, consisting of sectors of a cylinder, with pieces of one end of the cylinder attached, this end being made use of to connect the armature to the spindle which carries the two, the armatures being placed on opposite sides of a diameter of the copper cylinder in which they revolve, and one above the other. The working of the apparatus is as follows. The telegraph being at "Stop," the electro-magnets exercise such an attraction upon the two needles that the latter stand right across the copper cylinder, the pointers standing in the corresponding position. When a signal is made, the action of the lever on the dial on the bridge causes a disturbance of the condition of equilibrium in the copper cylinder. Some of the electro-magnets get an addition of current, while others receive a smaller current, with the result that the compound needle armature moves round in obedience to the pull of the electro-magnet that has received the larger current, and the engineer, on receiving the signal, shows that he has understood it by moving his lever round, causing the pointer on the bridge to move round and repeat the signal. Below the electromagnets are the resistances by means of which the rotation, caused by the variation in the current passing into the different electro-magnets, is produced. With the steering apparatus the signal is sent to the steering-house, and the helm itself repeats the signal as it is put over in obedience to the signal, a small belt from any convenient point working the lever, just as the engineer works it, over the dial, and repeating the signal to the bridge. The apparatus is shown in operation. The

ANOTHER VIEW IN THE BRITISH WESTINGHOUSE CO.'S PAVILION.

telegraph is illuminated by two incandescent lamps under the dial.

THE BRITISH WESTINGHOUSE COMPANY.

The Westinghouse Company have arranged a very fine exhibit. They have built a pavilion in Machinery Street, in which is a specimen of the now well-known Westinghouse gas engine, with three cylinders, each of 13-in. diameter and 14-in. stroke, the three cylinders delivering on to one crank-shaft, the three cranks being 120 degs. apart, as with the Willans engines. The engine is worked on the Otto cycle, but each cylinder takes its explosion in succession, so that a more even turning movement is obtained than where only one cylinder is used. The engine exhibited is designed to furnish 125 b.h.p. at 260 revolutions per minute, and it is directly coupled to a compound continuous-current six-pole dynamo furnishing 75 kilo-watts at 120 volts. The gas engine is started by the admission of compressed air to the cylinders twice in each cycle till the engine has got up speed and is taking gas in the ordinary way, when the air is automatically cut off. The supply of compressed air is obtained from a reservoir provided by a small air compressor driven by a strap from the engine shaft when the latter is running. The charge is ignited by an electric spark.

The Westinghouse Company have arranged a similar set of conversions to those already described in connection with other firms' exhibits. Thus the current from the compound-wound dynamo that is driven by the gas engine is delivered to a motor generator which transforms the service up to 500 volts continuous, and the current from the generator side of this is taken to an eight-pole continuous-current motor, designed for 325 kilo-watts, but which is arranged in this case to drive a cross-compound vertical steam engine, whose cylinders are 18 ins. and 36 ins. respectively by 42 ins. stroke,

but with no steam passing. The electro-motor has merely to overcome the friction of the moving parts of the engine. The current from the main generator also works a rotary convertor, which furnishes a two-phase current on the generator side at a pressure of 90 volts, the current from the rotary convertor being passed through two 25-h.p. stationary transformers which raise the pressure to 400 volts, at which pressure it is delivered to a 10 h.p. two-phase motor, the latter again driving a four-pole continuous-current generator from which the lamps are taken for illuminating the pavilion. Continuous-current and two-phase machines are shown in parts displaying the details of their construction; and a very pretty model is also shown, illustrating the revolving field of the induction motor, consisting of a circular field magnet with four coils, in the centre of which a star-shaped piece of thin iron is pivoted. When the current is sent into the field magnet, as in a two-phase motor, the star revolves.

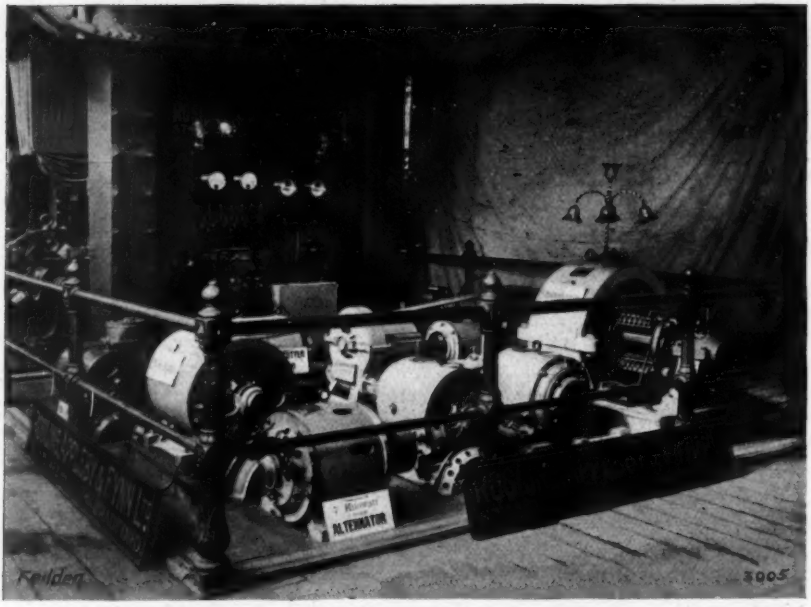
A very handsome traction switchboard is shown, occupying a portion of one end of the pavilion. Various specimens of Westinghouse motors are shown, and one side of the pavilion is occupied by a tramcar, capable of seating 70 passengers, 30 inside and 40 outside. The car is mounted on two bogies, each having a series-wound motor capable of furnishing 35 h.p., connected to the wheel axles by single reduction spur gearing. The car is also fitted with Milnes' electro-magnetic slipper brake, in which, for the first time, a satisfactory slipper brake has been worked out, the brake pulling the car wheels down to the rails, instead of pushing them away, as with the mechanical form of slipper brake. As the slipper brake goes on also, the same operation puts the ordinary peripheral wheel-brakes on, so that double effect is obtained. The current for the electro-magnet of the brake is obtained from the motors when operating as generators, as when going downhill. The car is also heated by current taken from the motors, or from the service. The car is controlled by the usual barrel controller, enclosed in iron, while the fuse, lightning arrester, switch, and circuit breaker, all of which are carried on the car, are all enclosed in iron. The Westinghouse Company have arranged a pit under the car, with steps, so that anyone who is interested can examine the apparatus for himself.

THE GENERAL ELECTRIC COMPANY.

This company has two stalls, one consisting merely of an engine and dynamo, and the other of some of the very numerous apparatus the firm manufacture. The engine is one of Davey Paxman's, made on Peache's patent. It is a triple crank engine, each crank being driven by a complete tandem compound engine, the cylinders being 10½ ins. and 17 ins. respectively by 11-in. stroke, and the speed 350 revs. per minute. It is directly coupled to a compound 6-pole dynamo of the General Electric Company's manufacture, designed to furnish 420 amps., at 500 volts. The brush rocker is made hollow, and the connecting conductors between the brushes are concealed inside it. It is claimed that the machine will work from no load to 25 per cent. overload without requiring the brushes to be moved, and without sparking.

MESSRS. DICK, KERR & CO. and THE ELECTRIC MANUFACTURING COMPANY.

This is a joint exhibit, and is devoted principally to apparatus connected with electric traction. The two most notable features of the exhibit are the large electric traction generator and the electric tramcar. The generator is a ten-pole continuous current machine, compound wound, weighing about 35 tons, and designed to furnish 500 k.w. at 550 volts, when running at 90 revolutions per minute. The armature weighs 15 tons. The brush holders are held by a strong bracket similar to the Crompton dynamo, and with four large carbon brushes, instead of a larger number of smaller ones. The conductors connecting the brushes are carried behind the ring supporting the brush holders. The field magnet cores are laminated, and cast into the field ring. The magnet ring is in two halves, and works on iron slides provided for the purpose, enabling the magnets to be removed to get at the armature, or at a coil of the field. One important



MESSRS. ROSLING, APPLEBY AND FYNN'S STAND.

feature claimed for the dynamo is the provision of equipotential rings, for balancing the coils. There are five of these rings, carried inside the casting which supports the commutator, and they connect the different points together, on the armature that ought to be at the same potential. There is an equaliser connection attached to the series winding.

The tramcar exhibited is one of the firm's standard four-wheel single-truck cars, with reversed stairways, and a seating capacity of 56. It is claimed that the reversed stairway, the stairway turning towards the car, instead of away from the car, gives increased safety to passengers, as the jerk on starting tends to throw the passenger on to the stairway, instead of off the car, as with the other form of stairs. It also enables two extra benches to be placed on the top of the car, and it provides a complete shelter for both driver and conductor. The car has two of Dick, Kerr's fully-enclosed 25-h.p. traction motors, connected to the axles of the car by single-reduction spur gearing. It is also fitted with rheostatic brake, with resistance for absorbing the current when not required for braking. The current passed into the brake varies from 30 amps. up to 120 amps., and for an emergency brake connection is made directly to the rails. The car is fitted with the usual barrel controller, lightning arrestors, fuses, circuit breakers, all in iron boxes. The lightning arrestors are fitted with impedance coils. The car is fitted in oak, as at Liverpool, Portsmouth, etc., where the firm have 400 cars running.

Messrs. Dick, Kerr also show a 100-h.p. fully-enclosed motor, as used on the City and Waterloo and the Liverpool Overhead Railways, also controllers of various patterns illustrating the different methods of control, for four motors and for two. They exhibit also a very interesting set of samples of points and crossings, in which detachable pieces of hardened steel are

placed where the wear occurs, fixed in place with white metal, so that they can easily be taken out and replaced. A joint for rails of improved construction is shown, in which the two rails are cut away on the off-side, and a planed steel plate let in flush and tight, so that the tread is alike from rail to rail.

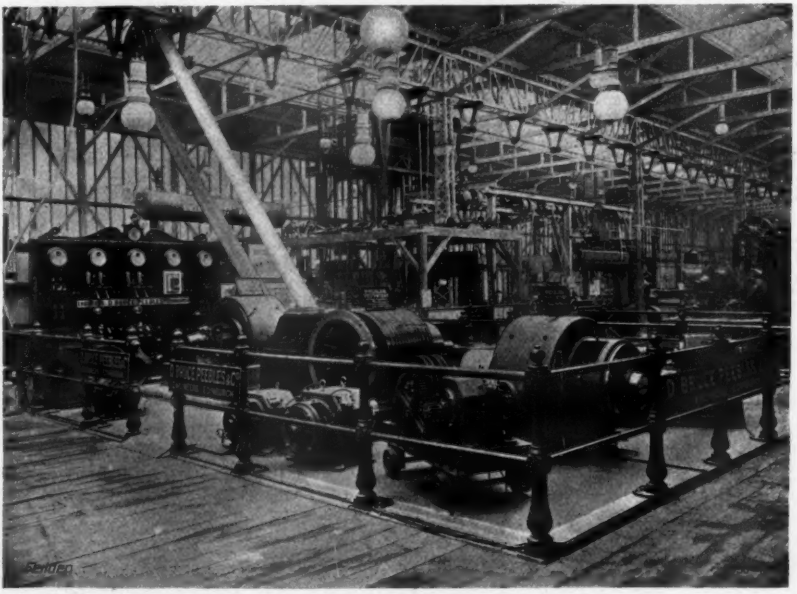
ELECTRIC COAL-CUTTING MACHINES.

Only two coal-cutting machines are exhibited, one by Messrs. Clarke, Steavenson, of Barnsley, and the other by Messrs. Mavor & Coulson, which represent the two methods of attacking the problem involved in long-wall working. Messrs. Clarke, Steavenson's stall is devoted entirely to the exhibition of their disc-cutting machine, which is shown revolving when required. The switches and resistances which the firm have found most suitable for the work, are also shown. As seen revolving on the stall, the disc, with its formidable teeth, looks a nasty apparatus to come in contact with—accidentally.

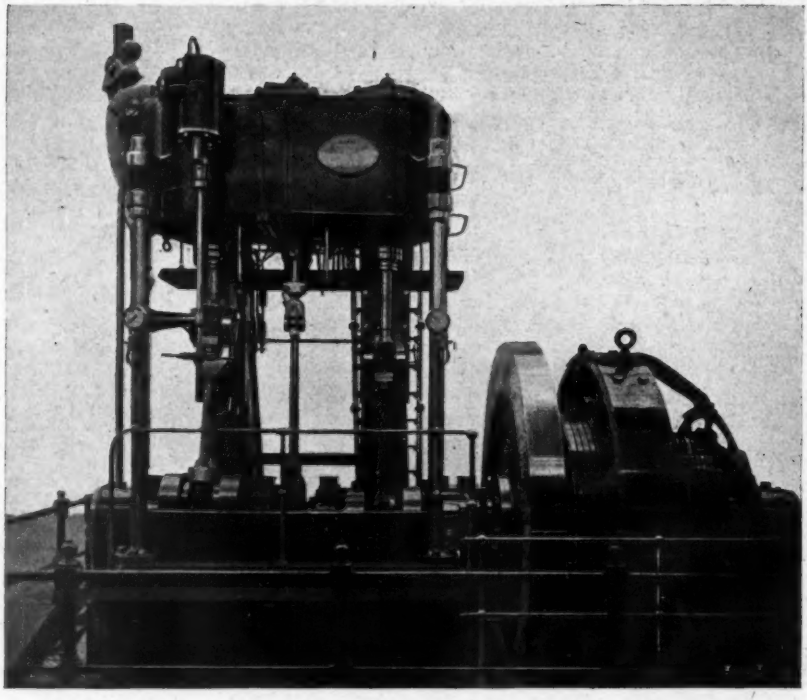
MESSRS. MAVOR & COULSON.

This firm exhibit Hurd's coal-cutting machine, in which a tapered bar, having cutting tools arranged along and around it, is caused to revolve, and so to hole under the coal. The firm's contribution to the plant in the generating station has already been mentioned. In addition they also run a Paul compound double-acting engine on their stall, which is directly connected to a four-pole compound dynamo, furnishing 150 amps. at 100 volts, the current from which is used at various stalls in the Exhibition.

Two interesting electric tools that should be mentioned are—a deck planer, consisting of an arrangement of knives sweeping the deck, the knives being driven by a hide belt from a small electric motor. The whole apparatus is arranged to run on wheels, with a pair of handles similar to those used with the ordinary wheelbarrow, so that it can be moved about where required. The spaee between the handles is made use of to carry the resist-



MESSRS. BRUCE, PEEBLES AND CO.'S EXHIBIT.



MESSRS. RICHARDSON, WESTGARTH AND CO.: VERTICAL CROSS-COMPOUND DYNAMO AND BROWN-BOVERI GENERATOR.

ance coils, starting gear, etc.; and a portable drilling apparatus, on something the same lines as the deck planer, the motor and starting gear being carried on a small wheeled truck with handles, and the drill connected to the motor by means of telescopic or flexible shafting. The motor for this portable drill is of ¾ h.p.

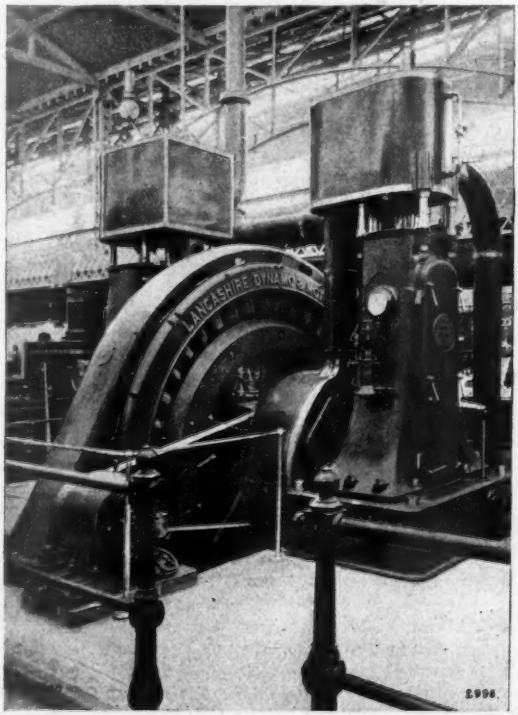
MESSRS. ROSLING, APPLEBY & FYNN.

This firm exhibit a four-pole generator, designed to furnish 440 amps. at 115 volts, when running at 540 revolutions per minute. It is driven by a motor taking current from the Exhibition supply service. The motor is arranged to take 61 amps. at 220 volts, when running at 950 revolutions per minute. They also show a two-pole completely enclosed motor directly coupled to a Sirocco fan, running at 1,700 revolutions per minute, also various patterns of their enclosed and semi-enclosed motors, the enclosed motors being of the same pattern as those supplied for use with coal-cutting machines, and claimed to be gas-proof; specimens of methods of reducing speeds from the high speeds at which electric motors always run to the low speeds sometimes necessary with the apparatus driven by the motors; in one case shown, a 2 h.p. motor fitted with worm gear is made to drive a vertical shaft, with a reduction of 25 to 1 between motor shaft and driven shaft; in another case, a 3½ h.p. motor drives a horizontal shaft by means of worm gearing with a reduction of 40 to 1 between motor shaft and driven shaft. Messrs. Rosling, Appleby & Fynn claim that, owing to care in design, to the use of cut steel worms and phosphor bronze wheels of correct shape and pitch, together with the use of ball thrust bearings, the efficiency of the

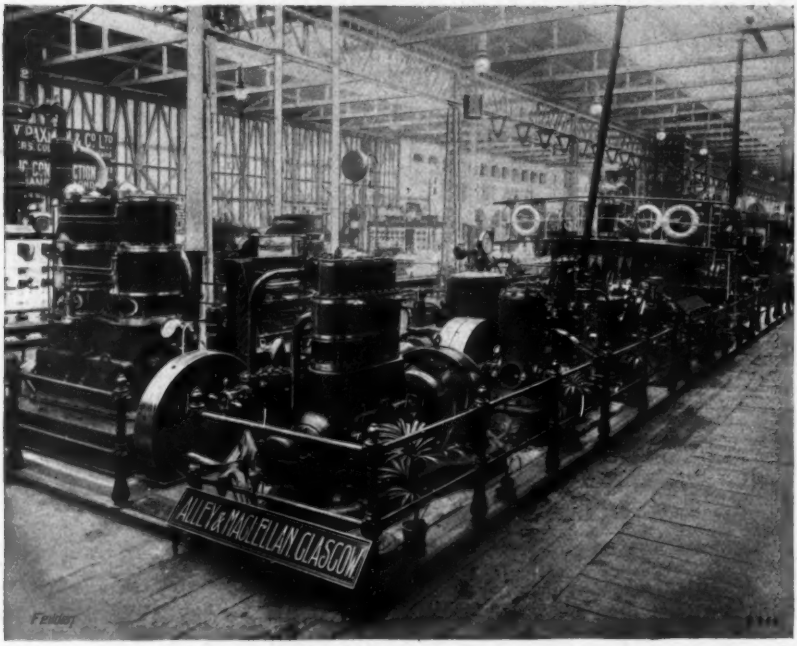
worm gears runs from 85 per cent. to 91 per cent. To everyone who has to do with apparatus driven by electric motors worm gearing having these efficiencies will come as an immense boon. Worm gearing is an ideal form of speed-reducing gear, but hitherto it has been obliged to be left out of the calculations of engineers, in spite of their strong wishes to the contrary, on account of the enormous proportion of the available power that was swallowed up by the gearing. The firm also exhibit samples of motors with second motion shafts carried on the motor case, geared to the motor shaft, so that when putting the motor down, only the reduction from the second motion shaft has to be considered. Samples of switchboards for different conditions are shown, also accumulator controllers. The firm claim that by their system of dynamo manufacture, on Mr. Fynn's patents, lighter machines are obtained for a given output, and that the whole construction, particularly the insulation where it is in the mechanical transmission line, is very much improved.

MESSRS. BRUCE, PEEBLES & CO.

The portion contributed by this firm to the generating plant has already been noticed. In addition, they supply a 150 h.p. motor which takes current from the power service at 500 volts, and drives the shafting on one side of the Machinery Hall, the shafting on the other side being driven by a 100 h.p. steam-engine as described. The motor runs at 350 revolutions per minute, and drives the shafting overhead by means of a 16-in. Hendry's laminated belt. In addition, the firm exhibit samples of motors of various sizes, made on their special patterns, also an endless rope haulage plant for mining work, driven by a series-wound four-pole motor designed to furnish 6 b.h.p. at 500 volts when running at 800 revolutions. The motor is geared to a pair of clip pulleys by means of double reduction spur gearing, the whole being mounted on one carriage made of steel, girder shaped, and mounted on four tram wheels to colliery road gauge. They also show an electric capstan, driven by a shunt-wound motor designed to furnish 8 h.p. at 460 volts when running at 880 revolutions per minute. It is geared to the capstan by worm gearing, the worm being of the single pattern, and it has two whip drums attached. This apparatus and the mining haulage plant are shown in operation.



HICK-HARGREAVES CROSS COMPOUND ENGINE AND THREE-PHASE GENERATOR OF THE LANCASHIRE DYNAMO CO.



MESSRS. ALLEY AND MACLELLAN'S STAND.

They have also a motor connected directly to a centrifugal pump running at 1,400 revolutions per minute, the motor designed to furnish 6 b.h.p. at 250 volts when running at the speed named; also samples of their switchboards, motor with first reduction attached, and their liquid resistance.

A recent addition to the exhibits consists of an interesting plant for train lighting which we hope to illustrate in another issue. The combined set weighs approximately 20 cwts. The engine is designed for a steam pressure of 150 lbs. per sq. in., and the dynamo for an output of 49 amps, at 106·5 volts, when running at a speed of 606 revolutions per minute. The overall space occupied by the set is: length, 5 ft. 9 ins.; breadth, 2 ft. 1½ ins. and 4 ft. 2 ins., thus rendering it particularly suitable for train lighting where only a small space is available and lightness is of importance.

The engine is of Messrs. Willans & Robinson's standard central-valve vertical high-speed enclosed type, and the dynamo is of Messrs. Bruce, Peebles & Co.'s standard multipolar type. The later will run without sparking from no load to over-full load without alteration in the position of the brushes, and the combined set will run silently and without vibration.

MESSRS. RICHARDSON, WESTGARTH & CO.

This firm, who are the agents in this country for Messrs. Brown, Boveri & Co., of Baden, Switzerland, have a very fine show. They exhibit a vertical Cross compound engine designed to furnish 600 h.p. when running at 150 revolutions per minute, with a steam pressure at the stop valve of 160 lbs. The cylinders are 16 ins. high pressure, and 31 ins. low pressure respectively, by 24 ins. stroke. The engine is directly coupled to a Brown-Boveri 10-pole continuous-current generator designed to furnish 1,250 amps.

at 240 volts when running at the speed named. It is compound wound, and the winding is arranged to raise the pressure 5 per cent., as the load rises. The brushes are arranged on the lines of the Crompton and Electric Manufacturing Company's dynamos, the field-magnet cores being cast solid with the magnet ring, as in the Schuckert dynamo. The whole machine is remarkably well designed and well made, there seems to be not an ounce of metal wasted anywhere, while every part where strains are likely to be met with is fully provided for. Several specimens of motors of Messrs. Brown, Boveri's make are shown, also their special controller for haulage and similar plant, by which the engine man is given complete control of his plant, yet can hardly make a mistake, the lever handle being similar to the engine lever he has been accustomed to, and it being arranged so that, while he turns the lever in the way he wishes his load to go, as with his steam-engine driven plant, the resistances automatically go in at their proper place and time. This apparatus is for three-phase work. The engine exhibited by Messrs. Richardson, Westgarth & Co., which is driving the large Brown, Boveri & Co.'s dynamo, is controlled by Morison & Weighton's patent slide valves. The special feature of this apparatus is, the two slides for the two cylinders are on one spindle and driven by one eccentric. The fly-wheel attached to the engine weighs 7 tons.

THE LANCASHIRE DYNAMO COMPANY AND MESSRS. HICK, HARGREAVES & CO., OF BOLTON.

This is a joint exhibit by the above-named firms. The principal exhibit consists of a Hick, Hargreaves & Co.'s cross compound engine of the vertical type, directly connected to a three-phase alternate-current generator made by the Lancashire Dynamo Company, the generator furnishing 5,000 volts and 23 amps. in each phase, or 230 kilo-watts in all. The alternator has 40 poles, and its armature forms the fly-wheel of the engine in the usual manner. The excitor is driven by five manilla ropes from a pulley on the boss of the alternator, and is arranged to furnish 80 amps. at 80 volts, when running at 500 revolutions per minute. The dimensions of the engine are: the high-pressure cylinder, 16 ins. diameter; low-pressure, 27 ins. diameter by 18 ins. stroke; and it runs at 150 revolutions per minute. The high-pressure cylinder has a piston valve, the low-pressure cylinder a slide valve; the governor is on the shaft, and the engine works with automatic expansion. The eccentrics and the governor are cased in to keep the oil away from them, and the whole of the bearings, etc., are supplied by forced lubrication, the oil pump being worked from the crosshead of the engine. The current from the three-phase generator is taken to a motor generator of 130 b.h.p. running at 600 revolutions per minute. The motor side receives the full 5,000 volts, and the generator side delivers continuous current at 500 volts. The generator is six-pole, and has six sets of carbon brushes, each set consisting of five carbons. The firm also exhibit a sample of the Corliss gear as supplied for the traction service at Leeds and Leicester; also cast-iron pillars with high-tension fuses, and transformers in iron cases, to convert from 5,000 volts to 200 volts.

There are various other exhibits distributed through the buildings and the grounds that space does not permit the writer to particularise more fully, but which are nevertheless full of interest. Electricity is everywhere, in all sorts of unlikely places, doing all sorts of things that one would hardly dream of applying it to, and apparently doing it well and in an interesting way.

Sydney F. Walker

NOTE.—The writer desires to correct two errors that have inadvertently crept into his report. The name of the electrical engineer who is in charge of the running of the generating station at the Exhibition, and who is also Mains Superintendent for the Electricity Department of the Corporation of Glasgow, is Mr. J. C. A. Ward, not Mr. Wall, as stated. Also it should be stated that the wiring of the Machinery Hall for light and power, together with the arrangements for the lighting, the selection of the arc lamps to be used, and the arrangement of the circuits inside the building was carried out by Mr. A. C. Freeman, the Assistant Electrical and Mechanical Engineer to the Exhibition authorities.

Glasgow International Exhibition.

By OUR SPECIAL COMMISSIONERS.

(Concluding Notice.)

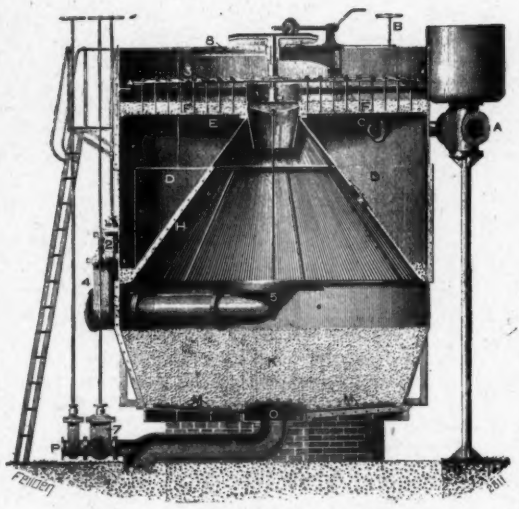
MESSRS. MATHER & PLATT'S EXHIBIT.

To go through Messrs. Mather & Platt's stall, and to do it thoroughly, is a very liberal education in itself. The stall is one of the largest in the Exhibition, and it has by far the widest range of exhibits, all of them of great interest from the engineer's point of view. The exhibits range from electrical apparatus in a great variety of forms to bacterial sewage plant, bleaching apparatus, water softening, filtering, fire appliances, and to apparatus for maintaining in cotton mills the requisite amount of humidity for facilitating the various processes of spinning. They show the largest dynamo in the Exhibition, though it is not running, and it is visible from a large portion of the Machinery Hall, notwithstanding the intervening exhibits. The dynamo illustrates in a marked manner the well-known feature of Lancashire, which persists in the electric light engines that the county sends out principally—viz. the massiveness and strength of all its parts. Lancashire mill engines are known all over the world for these characteristics, with their natural corollary that they work on from year's end to year's end without stoppage for repairs or anything else.

The exhibit is also characterised by another important feature which goes to show that this country is not so far behind in the race for industrial supremacy as some of us have been fearing. Every one of the exhibits, and the exhibits are only a selection of the firm's manufactures, shows in a very striking manner the hand of the scientist, and in the proper way. They show that in all cases the principles upon which the existing apparatus works, the root principles, have been very carefully studied, and that upon the basis of this study the new apparatus has been built up. And the results are as startling as some of the inventions that our American friends have given to the non-technical press. We have, for instance, centrifugal pumps connected directly to electric motors running at 1,000 revolutions per minute, and lifting water a height of 440 ft., and doing this with the same ease and absence of fuss that distinguishes a Lancashire mill engine. We have filtering apparatus sufficient for a town of 5,000 inhabitants taking up only the space occupied by a 20 h.p. vertical works steam boiler. We have bacterial sewage plant in which the sewage itself shunts itself into its proper path at the proper instant, so as to give the bacteria the rest they require after their labours of purifying the sewage, and giving that rest exactly for the right time, so that there shall be no waste of bacterial energy—no bacterial laziness, so to speak.

THE SEWAGE BACTERIAL PLANT.

Notwithstanding the dominant note which electrical apparatus strikes in Messrs. Mather & Platt's exhibit, as it does in the whole of the Glasgow Exhibition, perhaps the most interesting exhibit in their stall is the working model of the bacterial sewage plant. The offensive matter is got rid of, on the bacterial plan, by the successive operations of two forms of bacteria, the anaerobic bacteria and the aerobic form; those which do not like light and air and those which do; and, further, the aerobic form of bacteria, whose operations take the form of oxidising the material contained in the sewage, until it is no longer offensive, require the assistance of coke breeze for the work, and, in addition, they are only able to put in a very short time at work, hence it has to be arranged that the sewage shall pass in succession through

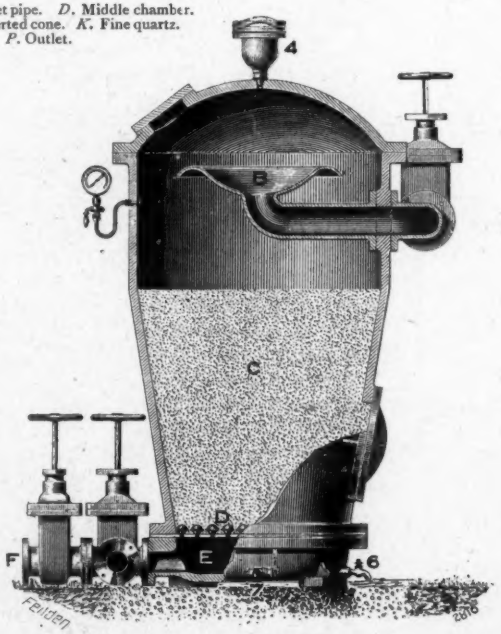


COMPOUND GRAVITY FILTER.

A and *B*. Inlet pipe and valve. *C*. Deflecting inlet pipe. *D*. Middle chamber. *E*. Perforated disc. *F*. Coarse quartz. *H*. Inverted cone. *K*. Fine quartz. *M*. Nozzles. *O*. Central duct. *P*. Outlet.

hydrogen and marsh gases, the fluid passes by a channel arranged for it to a distributing valve chamber, in which are the valves which are to perform the operation of diverting the sewage to the different beds in succession. There are seven such beds, and seven pipes, one to each bed, terminate in the valve chamber, and each pipe has its own valve, which is worked by a rod. As the sewage passes into the valve chamber, a portion of it—a shunt, as railway and electrical men would call it—passes into a separate chamber, in which a float is placed, which is connected with the rod which works the valve. The capacity of this measuring chamber is calculated, in pro-

tanks in which light and air will be absent and through tanks in which light and air will be present, and where coke breeze will also be present, and that the sewage shall be run off from the latter tanks after it has been in them a certain time (two hours), and the coke breeze beds allowed to rest for four hours. This is accomplished in the following ingenious manner, the working of which is fully shown in the model exhibited at Messrs. Mather & Platt's stall, the operation of the valves which carry out the distribution being illustrated by means of plain water. After the sewage has been in the first tank (the closed tank—that in which the anaerobic bacteria reign) for 24 hours, and the bacteria have done their work upon it by breaking up the solid matter and converting a large portion of the offensive material into



SINGLE CONTACT PRESSURE FILTER.

B. Overflow basin. *C*. Quartz. *D*. Nozzles. *E*. Collecting chamber. *F*. Outlet. 4. Air-escape valve. 6. Sample cock. 7. Steam-cock.

portion to that of the valve chamber, to lift the float when it is time to turn the sewage into another tank. The sewage passing into the valve chamber flows down the pipe whose valve happens to be open at the time, and on to the bed which it supplies. As soon as the sewage rises to a certain level in the measuring chamber the float rises, and, by a rack movement, works the rod in the valve chamber, closing the valve which is open, cutting off the sewage from the bed to which it has been passing, and opening the next in order, to which the fluid now turns, the measuring chamber at the same time emptying by an opening into the valve chamber. The dimensions of the measuring chamber are so arranged that the liquid is allowed to pass into each bed for one hour only. Each coke bed is also automatically discharged when the sewage has been in it for two hours, and this is effected by means of another valve which is controlled by a drum that is allowed to fill in the two hours required for the aerobic bacterial treatment. At the end of the two hours the weight of the fluid in the drum overpowers the opposing weight on the valve, which now opens and allows the fluid to escape. The sewage, as it was, as it now passes from the aerobic bacteria beds is without smell or colour, and can be allowed to run into rivers without any danger of pollution. The operation of the aerobic bacteria is oxidising—they practically burn up whatever impurities the anaerobic bacteria have left.

THE TOWN FILTER APPARATUS.

This is another apparatus designed, by simple means, to economise space, and to lessen the cost of rendering water pure for town supply. It is called Reeves' Compound Gravity Filter, and is to take the place of the filter beds used at present, which occupy a large space, and are open more or less to atmospheric influences. The apparatus consists of a cast-iron cylindrical vessel, which is divided into two portions by the walls of an inverted cone. At the top of the cylinder is a disc of finely perforated iron, on which rests the first filtering material, coarse quartz. The water to be filtered enters the middle chamber below the perforated disc, a centrifugal motion being given to it on entry; it then passes up through the perforated disc and coarse filtering layer, which extracts the coarser impurities. The partially filtered water, as will be seen from the accompanying drawing, then overflows into the bottom chamber through the hole in the centre of the inverted cone. In the lower chamber, on the floor, is carried a quantity of finely divided quartz, and through this the final filtering takes place, the water passing out at the bottom of the cylindrical vessel, through a system of pipes and nozzles. To clean the filter the operation is reversed. The filter is run dry, and water run through it, while the quartz is agitated by a mechanically driven rake provided for the purpose, the lower chamber being cleaned by simply reversing the flow of water. The operation of cleaning out is stated not to exceed 15 mins. A filter is shown which is capable of dealing with 125,000 gals. of water per day, which at the rate of 25 gals. per head, would be sufficient for a town of 5,000 inhabitants.

The firm also show a pressure filter made under Reeves' patents which is practically a small edition of the gravity filter, but intended to work with water under pressure. It consists of a slightly conical iron vessel, also containing quartz of different fineness, but distributed in one chamber, conical in form. The unfiltered water is allowed to pass on to the surface of the filter bed inside the chamber and to percolate down through the quartz, passing out at the bottom very much as in the gravity filter. The operation of cleaning is performed by reversing the flow of the water. The filter shown, which is the 3 ft. size, will deal with 2,500 gals. per hour, under a head of 30 ft.

FEED-WATER FILTER FOR BOILERS.

This apparatus is intended to remove all oil and similar matter from the water with which the boiler is fed, the filtering medium being sawdust.

ARCHBUTT & DEELEY'S WATER-SOFTENING APPARATUS.

This is another corollary of the filtering apparatus, and is another useful device for all boiler users. A model of the plant is shown in operation. As will be understood, it is intended to get rid of the troublesome effects caused by the presence of the carbonates and sulphates of calcium and magnesium in the water with which the boiler is fed.

GROUP OF CHEMICAL FIRE EXTINGUISHERS.

The apparatus consists of a cast-iron tank divided into two portions, one half being used alternately for the process of softening, and the softened water being drawn off from the other portion. A chemical solution is prepared in a separate tank, consisting of quicklime and sodium carbonate, boiled up together by means of live steam. When the tank is filled with the water to be softened, the chemically prepared solution is drawn into it by means of a steam injector, and when the water is thoroughly mixed with the chemicals the objectionable matter is caused to deposit on the floor of the tank by the ingenious method of stirring up the precipitate left by previous water, it being found that the matter in solution comes away very freely when attracted by matter of the same kind, which is present, and which is stirred up to receive it. The stirring up is effected by means of pipes placed on the bottom of the tank for the purpose. The pipes are perforated on the underside, and air is blown through them into the mass of matter which is lying on the bottom of the tank. After the solution has been stirred up for a few minutes, the steam and air are turned off, and the precipitate allowed to settle. In about an hour all the objectionable matter has precipitated, and the water can then be drawn off for use. It is stated that after proper use of this process not more than one grain per gallon of suspended matter will be found, even in the water near the bottom of the tank. A system of carbonating is added for special use with steam boilers.

FIRE EXTINGUISHING APPARATUS.

Filtering and softening water leads naturally to the use of water for other purposes, among which that of the prompt extinction of fire in mills and similar places is of great importance. The first of the apparatus exhibited is the well-known

GRINNELL'S SPRINKLER.

By the operation of this apparatus, in case of a fire breaking out in any room, a fine spray of water, under pressure, would be directed to any part of the room where the temperature had risen above 155

degs. F., and would keep up its sprinkling till the fire was extinguished or the apparatus destroyed; the town service, or a pump specially detailed for the work, maintaining the pressure, as the sprinklers lower it.

PUMPS FOR THE FIRE SERVICE.

Where the town supply water is used as an alternative with a steam pump for the main service in connection with the sprinkler, an automatic back pressure valve is fitted on the town side of the service to prevent town water being taken unless it is absolutely required. An automatic valve of very ingenious design also controls the action of the pump. The valve is itself elastic, and is controlled on one side by the pressure of water on the sprinkler system, the pressure actually available for sprinkling, and on the other side by an opposing spring. When the service is not in use the pressure of the service keeps the valve closed, but when a sprinkler opens, and lowers the pressure, the opposing spring comes into operation, and allows steam to pass into the pump, and the more the pressure is lowered, as it would be, the more of the sprinklers that opened, the more steam is allowed to pass into the steam cylinders of the pump, and the faster the pump works. When the sprinkler is not in use the pump is kept slowly revolving, so that there is no waiting when a fire breaks out, as there might be if the pump was at rest. In all cases where quick action is required, this is obtained best by arranging that the apparatus which is to perform the operation, whatever it may be, is, if possible, already in motion, so that only increased rate of motion is required, not starting up from rest. This is another of those points which show how carefully all the details of the different apparatus exhibited by Messrs. Mather & Platt have been worked out, and how well the scientific principles upon which all the exhibits are based are understood. The pump which is shown in operation in connection with the sprinkling apparatus is quadruplex, that is to say there are two distinct pumps, and each pump is double-acting. Also the valves of each pump are worked by the piston-rod of the other pump, so that the whole apparatus is very compact and efficient.

The pump shown has the following dimensions:—Steam cylinders, 18 ins. diameter; water cylinders, 10 ins. diameter; stroke, 12 ins.; speed, 100 to 150 revs. per minute; delivery, up to 1,020 gallons per minute. The steam-pipe is 4 ins. diameter, the exhaust steam-pipe 5 ins. diameter, the pump suction-pipe 12 ins. diameter, and the discharge-pipe 6 ins. diameter. The pump is made very strong and in every way in accordance with the factory fire insurance companies' requirements. The piston-rods are of bronze, and the water clacks and seatings of brass. There is also a provision made for altering the length of the stroke of the pump by altering the compression space in the steam cylinder, a wheel projecting outside the cylinder for the purpose.

OTHER PUMPS OF A SIMILAR TYPE.

Two other pumps are exhibited of a somewhat similar construction, but without the automatic arrangement, the pumps being intended for feeding boilers and work of that kind. Both are quadruple-acting pumps, but one is a steam pump simply, like the one shown with the sprinkling apparatus, and the other is a pump driven by either ropes or an electric motor. The steam pump has a steam cylinder 6 ins. diameter, a water cylinder 4 ins. diameter, and a stroke of 8 ins., and runs at 135 revolutions per minute, the total displacement being 98 gallons when working at that speed. The steam cylinders are suitable for boiler pressures up to 200 lbs. per sq. in.

The power-driven pump has water cylinders 8 ins. diameter, with a 10-in. stroke, and is capable of a total displacement of 654 gallons per minute, when running at 90 revolutions per minute. This pump is intended to be placed in any convenient position, and to be driven from any convenient source of power, such as the mill shafting, the power electric current, if there is one, the lighting service, etc.

One important feature which is common to all of these pumps should not be omitted. All of them are arranged so that the packing of the water rams can be adjusted from outside.

Another pump of this design, having water rams 3 ins. diameter and 6-in. stroke, is shown, driven by an electric motor, by means of a Renold's chain. The pump and motor, in this case, are mounted together on one iron casting, which forms the common bedplate, the whole apparatus being as compact as with gearing, and running very much more quietly. The pump shown is capable of producing a displacement of 61 gallons per min. at 100 revs. The electric motor which is driving it is one of the firm's E5 steel-clad type.

RECEIVER AND AUTOMATIC PUMP FOR STEAM HEATING.

This is also an ingenious apparatus. It is intended to return the water which has been formed from the condensation of the steam that has been used in heating the building by steam, as a portion of the feed water for the boiler from which it was taken originally. The condensed steam is led back into a receiver, to which is attached a pump, the pump being controlled automatically by the quantity of water in the receiver. When the water has reached a certain height in the receiver, a float inside the receiver chamber moves the required distance, and, in doing so, works a valve in a steam pipe which is led past the end of the receiver, allowing steam to pass into the pump steam cylinder. The pump then works, and continues to work, until the receiver is empty, when the same float closes the steam valve, and it remains closed till the water is again at the height at which the float is set to open the steam valve.

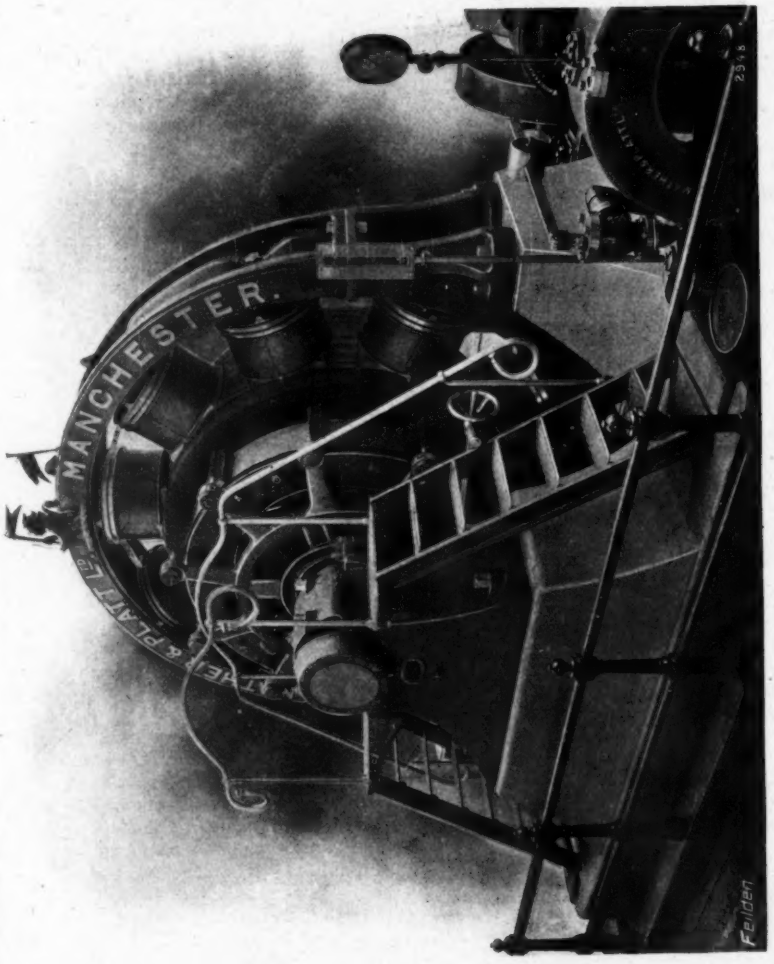
The apparatus shown is again a quadruple steam pump, having steam cylinders 5 ins. diameter, water cylinders 3 ins. diameter, and 6 ins. stroke, capable of delivering 45 gallons per minute. It is claimed that the saving of fuel effected by this apparatus is very great.

THE VORTEX HUMIDIFIER.

This is another simple scientific apparatus, designed to produce conditions favourable to cotton spinning that are not always to be obtained naturally. Dry cotton, when exposed to friction, as it is when passing through the jenny, generates electricity at high tension, which has the property of making the materials in which it is developed mutually repulsive, so that, when able to do so, the cotton threads stand out from each other, instead of lying closely together as they are required to do for convenient spinning. Fortunately, cotton has another property, it is very porous, just like a sponge, and another property of the group of materials which are able to generate electricity at high tension when exposed to friction is their inability to keep the electric charge when exposed to moisture. The apparatus which Messrs. Mather & Platt show is intended to cure the cotton threads of the desire to stand out from each other by taking advantage of its spongelike nature and the property of neutralising the electric charge, which the presence of water produces. A jet of water is led into a chamber under pressure, and being split up into fine spray induces a strong current of air, finally passing out at the apertures at the base of the apparatus. The humidified air thus diffused into the mill, is greedily sucked up by the cotton, producing the same result as would be produced by a naturally damp atmosphere. As only a portion of the water which is delivered to the chamber is used by the air current, whatever is not used is carried back to the tank from which the pump takes its supply, so that there is no waste. The air supply may be taken from the room in which the humidifier is placed, or from the outside atmosphere; in the latter case the apparatus acts as a ventilator as well as a humidifier.

ARMOURED FIRE DOORS.

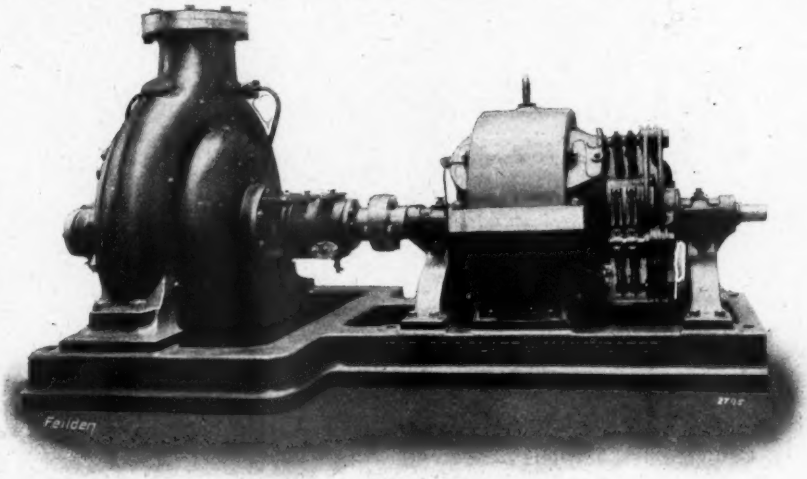
These are another adjunct to the numerous fire-resisting appliances shown by the firm, and they are made on a distinctly novel plan. Instead of forming



800-KILOWATT GENERATOR.

the doors of solid iron or steel, they are formed of wood, plated with sheets of tinned steel, which are fastened to the doors in such a manner that while the sheets themselves are free to expand, they exclude the air from the wood underneath, and cannot become detached. The wooden portion is made of three or four thicknesses of well-seasoned pine boards, planed, tongued, and grooved, and properly secured together. It has been found that these armoured doors are much superior in case of fire to solid steel or iron, and for the following reasons:—One of the reasons why fires limit combustion, and as they are allowed to expand without becoming displaced, they also maintain the closure of the aperture they are intended to guard.

By a simple and ingenious contrivance the armoured doors are made to close automatically when required, so as to shut off communication with portions of the building which may not have been attacked by the fire. The door which is to close automatically is hung by rollers on an inclined iron bar, and is kept open by a rope passing over a pulley, with a weight attached. When a fire occurs, as soon as the temperature reaches 155 degs.



PATENT HIGH LIFT CENTRIFUGAL PUMP.

are so disastrous in modern buildings is the great expansion which takes place in all iron or steel portions of the structure, the enormous expansive force practically wrecking the buildings. The same thing applies to doors, which are naturally made very heavy. They expand, and soon cease to perform the office they were intended to; and, in addition, the enormous forces developed by the expanding metal do a great deal of damage. With the armoured door, on the contrary, the steel sheets perform one very important office; they keep the air from the wood inside, and so Fahr., the weight is released by the melting of a fuse, and the door slides down the inclined plane into its position. Models of both forms of doors are exhibited.

THE ELECTRICAL AND ALLIED EXHIBITS.

The electrical exhibits themselves would provide enough for a good-sized stall. They cover a large portion of what is known as the electrical engineering industry.

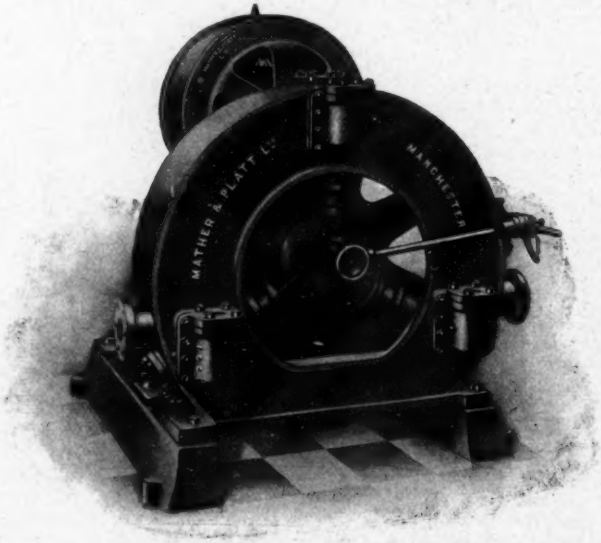
THE LARGE DYNAMO.

This has already been alluded to in the preliminary remarks. It is made to furnish 800 kilowatts, at 100 revolutions per minute, and it weighs 50 tons, the arma-

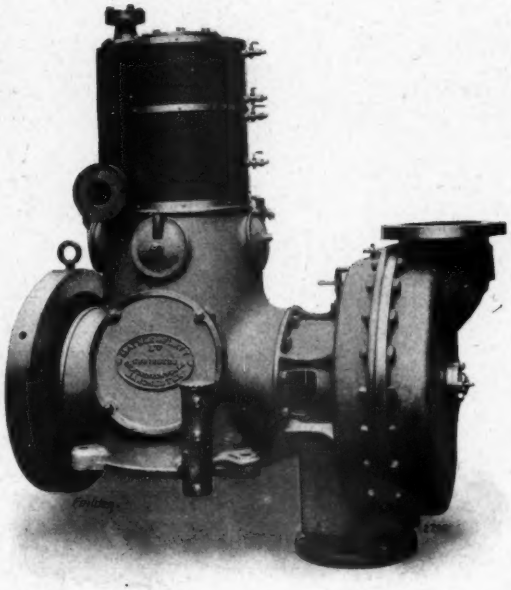
ture alone weighing 25 tons. It has ten field magnet poles, the cores of the field magnets being held on the inside of a steel ring, to which they are bolted. It has ten sets of brushes, each set consisting of nine carbon brushes having radial feed motion; that is to say, as the brushes wear they are fed automatically towards the commutator, in a radial direction. The brush-holders are of aluminium, and the brush spindle is arranged eccentrically with its ebonite bush, so that it can be adjusted radially and circumferentially for $\frac{1}{4}$ in. The armature shaft is 15 ins. diameter, and is hollow, the internal diameter being 4 ins. The commutator has 600 segments, and the pressure of the machine shown is 525 volts when working as compound, and 480 volts as shunt. The connecting rings between the different brushes are of stout copper carried inside the hollow central space of the commutator. The armature, commutator, and the whole machine are solidly and substantially built up, so that one would expect the machine to run as the Lancashire mill engines do, year in, year out, without attention.

THE SPECIAL ELECTRICALLY-DRIVEN THREE-THROW PUMP.

One would like to recommend two classes of scoffers to come and study this pump. One is the artistic soul who can see no poetry in engineering because oil and grease are used, and the other is the man who believes that mathematics are of no use. This is an apparatus which represents the poetry of engineering, and it also shows in a most remarkable manner the use of mathematics as a servant. The apparatus solves a problem which is often a very troublesome one; it does so in a most artistic manner, and the problem could only have been solved in the manner in which it has been by the aid of mathematics. The problem to be solved is that of a pump whose work is varying, but which is to be driven always at one speed by an electric motor. The ordinary plan adopted is to increase or decrease the speed of the pump according to the quantity of water to be raised in any given time; but with some forms of electric motors, especially those which are worked with polyphase currents, the variation of speed allowable is limited, and with all forms of electric



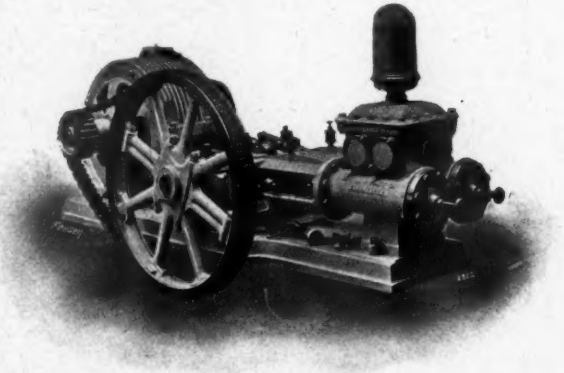
ELECTRICALLY-DRIVEN THREE-THROW PUMP.



ENGINE-DRIVEN CIRCULATING PUMP

motors variation of speed above a certain figure is always troublesome, and needs special arrangements to carry out, the apparatus for which are often out of place in the positions where pumps driven by electric motors are required to be used, and lead to waste of energy and loss of efficiency. Hence an apparatus which enables the pump to be driven always at one speed, and which also allows of the quantity of water pumped being regulated by the requirements of the load, is of great value.

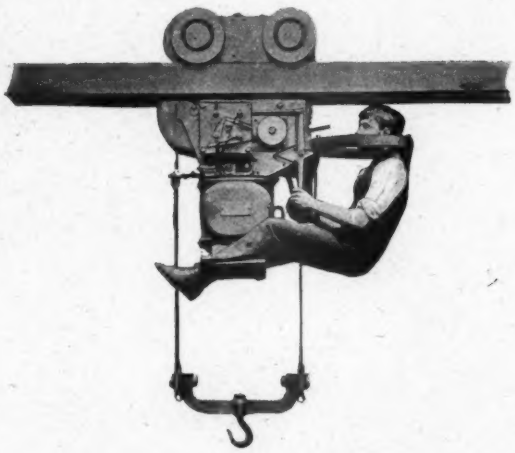
There are only two methods of altering the output of a pump—by altering the number of strokes it runs per minute and by altering the length of the stroke, and the latter method is very rarely used, because it is so difficult to arrange. It is this method which is used in the pump under notice. The three pumps are arranged in a circle around a central shaft, the three pump rods being worked in turn from a crank-pin in the usual manner. The frame of the pump carries the motor, which gears to a wheel on the main shaft before referred to by spur gearing. The pump crank-pin and the main driving shaft, which receives its motion from the wheel driven by the electric motor, are arranged in sun and planet fashion, and that is the manner in which the alteration of the stroke is arranged. Assuming that the main shaft represents the sun, and the pump crank-pin represents the planet, the diameter of the orbit of the planet will represent the length of the stroke of the pumps. Thus, if the crank-pin be made to run concentrically with the main driving shaft, the stroke is nil, and the pump is doing no work, except that involved in overcoming its own friction. It is pumping no water.



RAM PUMP DRIVEN BY AN ELECTRIC MOTOR AND RENOLD'S CHAIN.

If the crank-pin is gradually moved out from this concentric position, the stroke of the pumps increases with it, till at its extreme position the stroke is at its longest. And this is what is done in the pump under notice. The crank-pin and the main shaft are attached to two discs which revolve together, the disc to which the crank-pin is attached being eccentric to the other. It will be seen, therefore, that the crank-pin, occupying a certain position upon the eccentric disc, can be brought towards the concentric position, or away from it, by causing the eccentric disc to revolve with reference to the other disc, the motion being, as described above, equivalent to decreasing or increasing the length of the stroke. And this revolution of the crank-pin disc, with reference to the main driving shaft disc, is brought about in a very beautiful manner. Motion is communicated to the two discs by means of gearing from the spur wheel, which is driven by the motor pinion, and the reduction in the speed that is necessary for the pumps is produced by passing the gearing through a box of epicyclic gear carried by the outer end of the main shaft, a special arrangement of two sets of worm gearing producing the motion of the second eccentric disc. In the box are two wheels which give motion to two pulleys that appear on the outside of the box, and upon which friction apparatus can be brought to bear if desired. When the pump is running, and it is not desired to alter the stroke, the whole thing revolves together, in the several positions that have been given them—the two discs, the two shafts, the epicyclic gear, etc. If, however, the motion of either disc is arrested, motion will take place relatively between the two discs, the eccentric disc revolving round the other, and in doing so bringing the pump-shaft nearer to or farther from the position in which it is concentric with the main driving shaft. And this is what is done: The pulleys on the outside of the epicyclic gear-box revolve within brake bands, which are attached to the end of a lever pivoted on the side of the frame of the pump. As long as no alteration of the stroke is required the pulleys revolve quite freely, so far as this brake band is concerned; but if a change in the length of the stroke is required, the fork is inclined to one side or the other, braking the motion of one of

HIGH-LIFT CENTRIFUGAL ELECTRICALLY-DRIVEN PUMP.



ELECTRICAL CONVEYOR.

the pulleys, and in so doing causing the motion of the eccentric disc around the main driving disc, thereby altering the stroke, the operation only taking a minute or so, the time required for the two discs to assume the new position. An indicator is provided on the framework of the apparatus to show the length of the stroke, and the quantity of water the pump should be raising, or the pressure produced. It will be seen that it can be arranged, without difficulty, to work the gear which regulates the length of the stroke by electricity from a distance, or automatically by the water itself. The pump shown has rams $3\frac{1}{2}$ ins. diameter, with a stroke varying from 0 to $4\frac{1}{2}$ ins., and is driven by a $7\frac{1}{2}$ h.p. electric motor, taking current from a 200-volt circuit at 550 revolutions per minute.

THE HIGH-LIFT CENTRIFUGAL ELECTRICALLY-DRIVEN PUMP.

This is another novelty of a somewhat startling character. The apparatus shown runs at 1,400 revolutions. The pump and the motor are mounted together on one cast-iron bedplate, the pump being directly coupled to the motor shaft. An efficiency of 70 per cent. and in special cases as much as 75 per cent., is claimed, this and the high lift being possible by the shape and proportions of the water passages, and by the provision of a whirlpool chamber and the shape of the fan-blades. The water enters the revolving wheel axially, and, in the case of the single pumps, symmetrically on each side, so that the axial thrust is eliminated; it then traverses the curved passages of the wheel, and is discharged tangentially at the periphery into guide passages, which convey it to the whirlpool chamber. The apparatus is shown working in a manner to attract considerable attention. The delivery pipe of the pump is taken to a pipe with a conical passage, having a fire nozzle at the end, so that a pressure is produced, which is shown on a gauge attached to the pipe, of 25 lbs. to 35 lbs. per sq. in., according to the speed at which the pump is running.

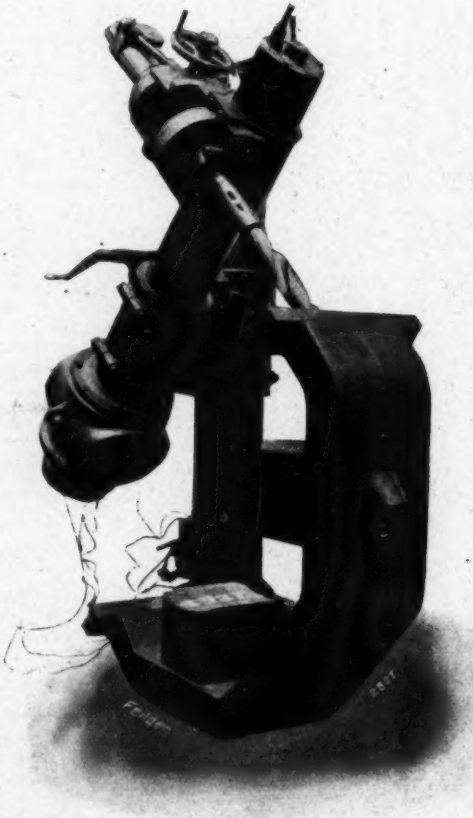
A larger form of this type of pump is also shown, one of a pair that have been ordered by the Corporation of Newcastle-on-Tyne. It is capable of pumping 1,250 gals. per minute a height of 95 ft. at 700 revolutions per minute, and is directly connected to one of the firm's four-pole motors arranged to furnish 50 b.h.p. when supplied with continuous current at 500 volts.

Messrs. Mather & Platt have made a very interesting installation at Newcastle in connection with this order. The pump is arranged to lift water from the River Tyne to the central generating station on the hill, for the surface condensing plant. After it has done its work in the condenser, what is left of the water is allowed to run back to the river again, but as it is evident that in running back to the river it will do work equivalent to that which was done upon it in lifting it, less the charges for friction, etc., the firm have fixed a turbine for the water to pass through on its way back to the river, and the turbine is connected mechanically to

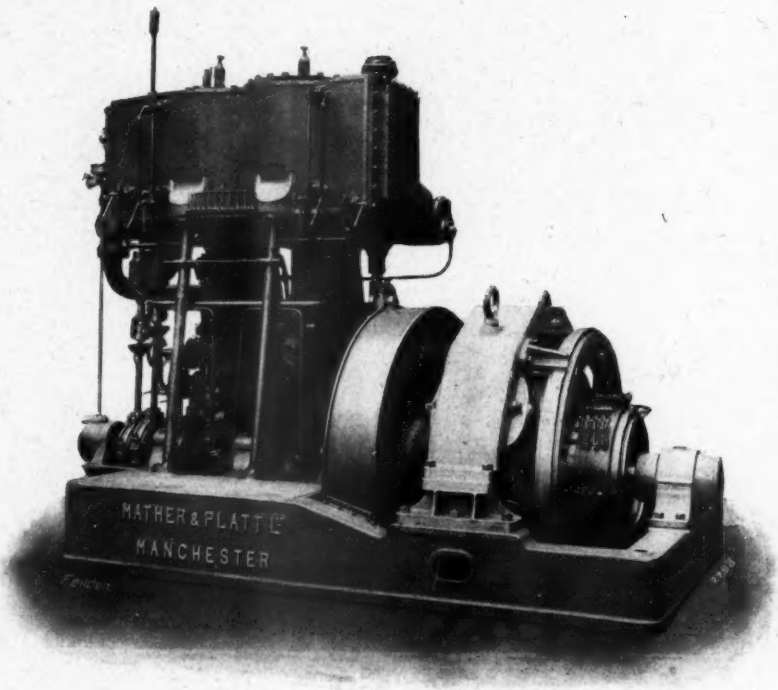
the axle of the motor that is driving the pump. So that all the energy the driving current has to supply is that necessary to overcome friction, and to provide for the charges for conversion, and the water wasted. This is economy.

THE ELECTRICAL CONVEYOR OR OVERHEAD RAILWAY FOR PARCELS, ETC.

One of the striking features of Messrs. Mather & Platt's exhibit is Aspinall's conveyor, which is made by the firm, and which may be seen in actual useful work at the Victoria Station, Manchester. Every one who is familiar with Manchester stations will recognise what an immense boon an apparatus of this kind must be. The arrangement consists of two rails, suspended in air at a convenient height, so that parcels and other things that are to be handled can be carried above the heads of the general public using the platforms, and that the lad working the apparatus can see what is going on below. The rails are supported by hangers suspended from the roof, and the width of the track—it is a railway—is from 11½ ins. to 13 ins., as desired. On the rails runs a carriage, having double-flanged wheels which are insulated from the axle and from other parts of the apparatus. Attached to the carriage is a framework which carries the electric motor, the seat for the driver, and the arrangements for lifting and holding the parcels, etc. The motor lifts the goods to be handled by means of gearing provided for the purpose, and having lifted, it transports them along the track in the required direction, just as a lifting and travelling crane does. The current is delivered to the motor by the rails, passing to the motor by one rail and returning by the other. The motor delivers its power to the lifting and traversing gear by means of a double-faced friction pulley carried by a vertical shaft directly connected to the motor-shaft, the friction pulley being moved up or down, as required, to engage with the hoisting or travelling gear, by means of a lever which is placed close to the driver's hand. A second handle controls the motor switch. The load is carried by steel ropes coiled on a drum. In the apparatus shown, a basket similar to those used by the Parcel Post is hoisted and carried the length of the stall while the visitor is looking round. It has a 1¾ h.p.



PORTABLE ELECTRIC DRILL.



135 KILOWATT COMBINED PLANT.

motor, which runs at 700 revolutions per minute and is able to lift a weight of 15 cwt. at 26 feet per minute.

THE SELF-CONTAINED ELECTRICALLY-DRIVEN RADIAL DRILL.

This is an apparatus designed to meet the growing demand for tools that can be taken to the work, instead of the work being taken to the tool. It is a radial drill, similar to many that are in use, but with the addition that the radial arm is extended on the opposite side to that which carries the drill, and on this extension is fixed an electric motor. The reducing gear, switch, and starting gear are all carried on the body of the machine itself, so that all that is necessary is to place it in position, connect its terminals to the supply service, and start. In addition to the above features, it will be noticed from the illustration that the apparatus is portable. It is also provided with an electro-magnet, concealed in the base of the pedestal, which can be used to make it adhere to any iron plate or iron floor, etc., on which drilling may be carried out. The spindle is geared directly to the motor shaft, and drilling can be carried out in any position, vertical, horizontal, or at an angle, with equal facility. The current for the magnet is taken from the same source as that for the motor. This is one of the instances of the growing use of the electro-magnet for holding and lifting. The apparatus shown has a main column 7 ft. high and 12 ins. in diameter. The radial arm is 8 ins. in diameter, the drill spindle being $2\frac{3}{4}$ ins. The motor is of the two-pole enclosed type, capable of developing 2 h.p. at 800 revolutions per minute, and

is connected to the switch by a flexible cable. The motor can be wound for any pressure desired.

The sole licence for the manufacture of this drill has been placed with the Atlas Engineering Co., of Levenshulme, near Manchester.

THE STEAM ELECTRICAL GENERATING PLANTS.

Two self-contained steam dynamo plants are shown, the engines and dynamos being carried on one bed-plate in the usual manner. One consists of one of the firm's compound open type vertical marine engines, driving one of their multipolar generators, the plant being capable of furnishing 650 amps. at 210 volts, or 750 amps. for short periods, at 180 to 190 revolutions per minute. The diameters of the cylinders are 14 ins. high pressure and 24 ins. low pressure, with 16 ins. stroke. Another feature in connection with this plant is a Pickering governor operating the throttle valve, and a slide valve which is arranged to be adjusted by hand, according to the load, a scale being provided for the engine man to work to.

The other plant is also of the same type, with cylinders of 9 ins. and 17 ins. diameter, by 12 ins. stroke, driving a multipolar dynamo capable of furnishing 350 amps. at 200 volts, at a speed of 230 revolutions per minute, or 400 amps. for a short time. This engine is fitted with the firm's shaft governor, the special features of which are, that it is very powerful in construction, thus giving great governing power, very powerful springs being opposed to very heavy weights, with long bearing surfaces, which are lubricated by centrifugal force from the centre. The governor operates a piston valve by altering the throw of the eccentric.

THE ENCLOSED ELECTRIC MOTORS.

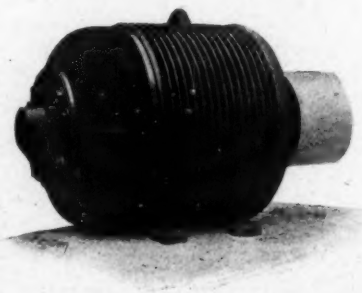
A number of these are shown, of various sizes and types. One main set of features runs through them all: they have all been designed to furnish a large radiating surface, which is accomplished by the corrugations of the outer case, and they are all arranged so that they can be made as open type, semi-enclosed, or as completely enclosed.

THE HIGH-SPEED ENCLOSED ENGINE WITH DIRECT-DRIVEN MATHER-REYNOLDS PUMP.

This is a specimen of the firm's quickly revolving engines, coupled to one of their turbine pumps. The engine is of the vertical tandem type, the cylinders being 7½ ins. and 12 ins. in diameter, by 5 ins. stroke. The pump has no foundation, being merely bolted to the frame at one end of the engine, and balanced by the flywheel at the other, so that the floor space occupied is only 5 ft. by 4 ft., the capacity of the pump being 1,200 gallons per minute against a head of 30 ft. when running at a speed of 480 revolutions per minute.

This completes the main features of Messrs. Mather & Platt's exhibits, and those who have had the privilege of inspecting the plants and specialities under review will undoubtedly have come away strikingly impressed with the resourcefulness, skill and enterprise which have always characterised this well-known and highly respected firm.

Those unfortunate enough not to have visited the exhibits will, it goes without saying, receive every courtesy at the works of Messrs. Mather & Platt in Salford, Manchester.



ENCLOSED TYPE MOTOR.

MISCELLANEOUS EXHIBITS.

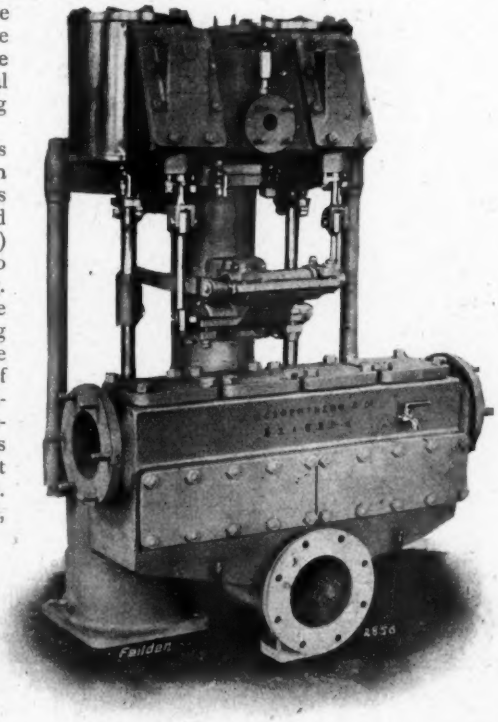
MESSRS. J. H. CARRUTHERS & CO.,

engineers and steam pump makers, Polmadie Ironworks, Glasgow, supplied for the pump-room two vertical compound duplex pumps (Fig. 2) for feeding the main boilers which supply steam to the Exhibition. Each of these pumps, when making forty revolutions per minute, is capable of feeding 6,000 gallons per hour. The endeavour that now prevails to reduce steam consumption attaches some interest to these pumps, which embody the most recent design and economic principles.

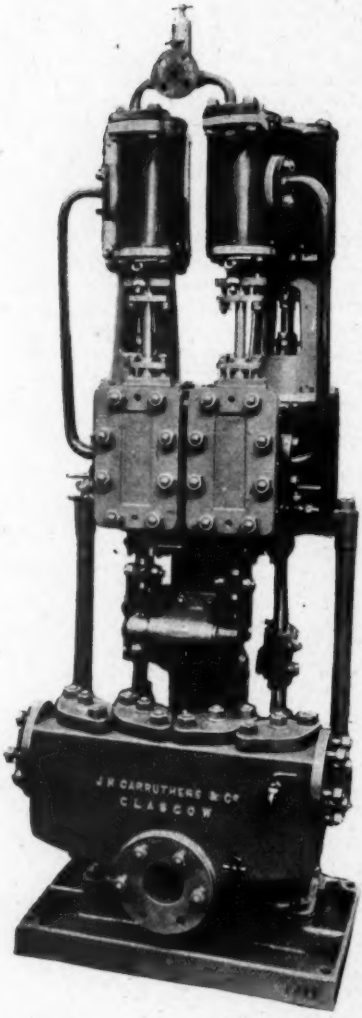
At the stand of this firm in the Machinery Hall were shown in motion—a vertical singlex boiler feeding pump; a vertical duplex boiler feeding pump, with automatic control float and valve, regulating the speed of the pump to the supply of water to be pumped. There is also shown in action a low-service or ballast pump (Fig. 1) of vertical duplex type, capable of delivering 250 tons of water per hour.

A further exhibit by this firm is List and Munn's patent gravitation feed-water filter. One is shown as made for the mercantile marine and for land purposes; another (Fig. 3) is shown which will be fitted into one of H.M. ships now building. In these filters the area of the outer stratum alone of the filtering surface is generally about one thousand times that of the area of the feed-pipe, the speed of the feed-water through the filter being proportionately reduced. This enables the impurities in the water to deposit quietly on the filtering medium. Besides this great advantage, the impure water has to pass through at least two or more strata of filtering medium, thereby securing the greatest efficiency and certainty of extracting all grease from the feed-water.

Fig. 4 shows an independent surface condensing plant for dealing with 18,000 lbs. of steam per hour. The air and circulating pumps, which are both double acting, are attached to strong girders, and support the surface condenser. The pumps are worked from compound steam cylinders in line with and between the pumps. The engine is of the singlex type, and this plant can be delivered at its destination, the condenser in one piece and the engine in another, each weighing about 5 tons. Fig. 5 illustrates a compound jet condensing horizontal duplex pumping engine, made to deliver 1,000 gallons of water per minute against 160 lbs. pressure per square inch. Fig. 6 shows an automatic valve applied to these engines to prevent accident from over-pressure in the pumps and from sudden reduction of water pressure, such as might be caused by breaking of pipes. The



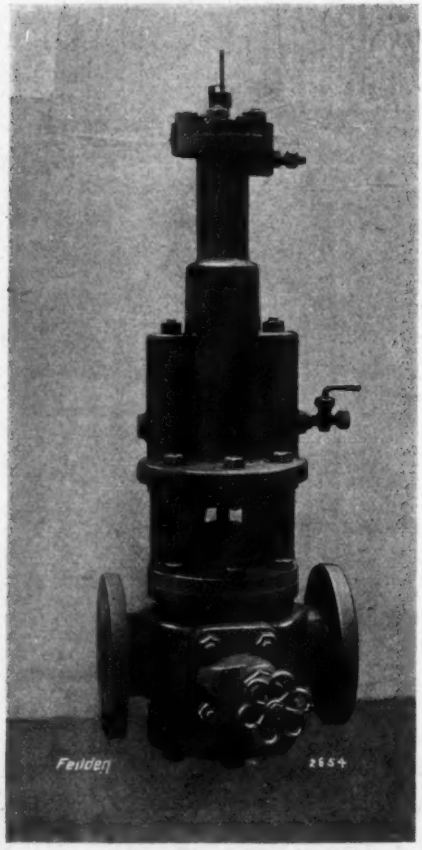
MESSRS. J. H. CARRUTHERS AND CO.:
VERTICAL LOW-SERVICE DUPLEX PUMP. (FIG. 1.)



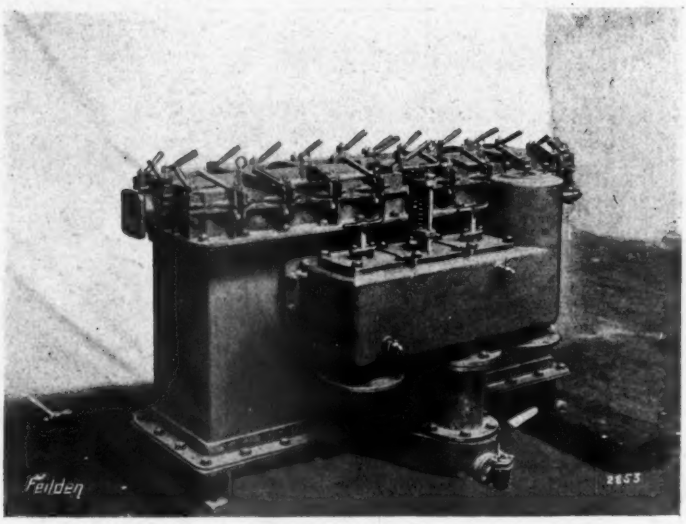
MESSRS. J. H. CARRUTHERS AND CO.:
COMPOUND VERTICAL DUPLEX FEED-PUMP.
(FIG. 2.)

design of this engine indicates careful consideration of subdivision of parts for facility of transport and re-erection, and for giving great freedom of access to all parts for examination and repair. We understand this engine was designed, and four engines were made and shipped, by Messrs. J. H. Carruthers & Co. within nine months.

At the stand of Messrs. Mavor & Coulson Messrs. Carruthers had one of their triplex or three-throw motor-driven pumps, suitable for working against a pressure of 400 lbs. per sq. in. The motor is of Messrs. Mavor & Coulson's manufacture, and the pump is driven from it by a raw-



MESSRS. J. H CARRUTHERS AND CO.:
AUTOMATIC OVER-PRESSURE AND BREAK-PRESSURE
RELIEF VALVE. (FIG. 6.)

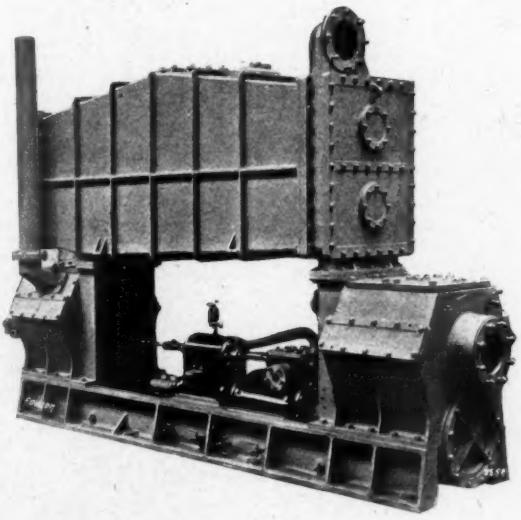


MESSRS. J. H. CARRUTHERS AND CO.: FEED-WATER FILTER. (FIG. 3.)

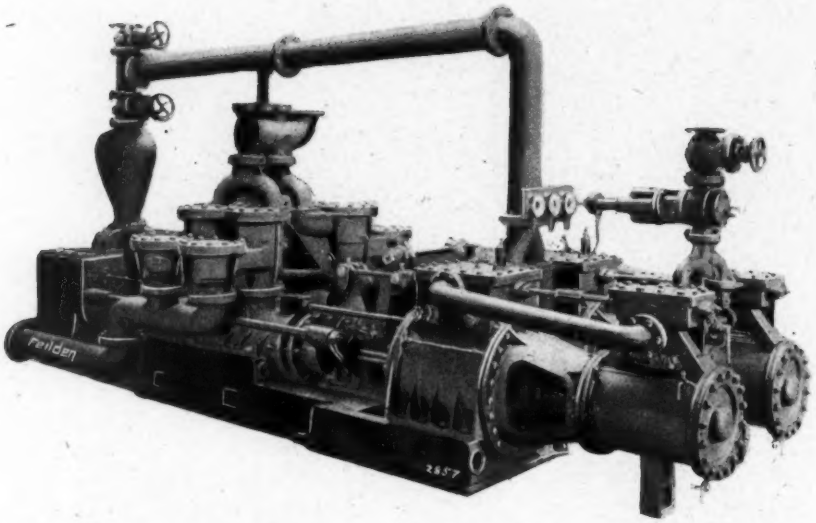
hide pinion and cast-iron wheels with machine-cut teeth.

MESSRS. T. S. McINNES & COMPANY, LTD., 41 & 42, Clyde Place, Glasgow, and MESSRS. ALEX. DOBBIE & SON

had a joint exhibit of the "McInnes-Dobbie" indicator. In the original "McInnes" indicator instrument the pencil arm and motion links do not move in a central plane, and the pencil arm, which is a straight bar, is not placed directly over the piston rod, but is set to one side in order to move clear of the cross links and fulcrum bracket. This overhanging arm, having a side strain, tends to bend the joint pins, and the friction thus set up results in a considerable drag on the linkage, and in unnecessary and serious wear of the sockets and pins. In the new "McInnes-Dobbie



MESSRS. J. H. CARRUTHERS AND CO.: INDEPENDENT AIR AND CIRCULATING AND SURFACE CONDENSING PLANT. (FIG. 4.)



MESSRS. J. H. CARRUTHERS AND CO.: HORIZONTAL DUPLEX COMPOUND JET CONDENSING ENGINE. (FIG. 5.)

Indicator" this motion gear is, theoretically, identical with that on the older "McInnes" instrument, inasmuch as the joints, fulcra, and marking point are in the same positions relatively to one another; but instead of using straight links throughout, the long lever carrying the marking point is cranked in such a manner that it is no longer overhung to clear the fulcrum bracket, but is mounted so as to intersect the vertical axis of the pressure cylinder, receiving consequently a more harmonious and direct motion from the piston, with less liability of error due to friction.

MESSRS. J. & E. HALL, LTD.,

of Dartford, exhibited two refrigerating machines, viz. their No. 8 Marine type machine, and, in connection with this, a sectional model of a portion of a ship showing the refrigerated chambers as fitted for passengers' use, the chambers being fitted up with pipes in the usual way. Also a water-cooler combined with a cold cupboard such as they fit in pantries on passenger steamers, the cold cupboard being for keeping wines, small stores of ice, &c., &c., for immediate use. One of their marine type ice tanks was shown in use, as was also No. 2 land type CO_2 machine arranged with electric motor combined.

J. & E. Hall's patent dry air carbonic refrigerating machines are very simple, and consist of the following three parts:— 1. The compressor (the only moving part) in which the gas drawn from the evaporator is compressed. 2. The condenser, consisting of coils, in which the compressed warm gas is cooled and liquefied by the action of cooling water. 3. The evaporator, consisting of coils, in which the liquid carbonic anhydride evaporates, producing any degree of temperature that may be required down to 80 degrees below freezing point. The charge of carbonic anhydride originally put into the machine is used over and over again, going progressively through the processes of compression, condensation and evaporation. Thus a small quantity only is required to be added from time to time to replace any small losses.

The vertical marine type, for preserving provisions on passenger steamers and

steam yachts, making ice, etc., is constructed with compound steam cylinders, and two compressors. In connection with each compressor is a condenser and evaporator, so that there are two quite complete and independent carbonic anhydride systems, either of which can be disconnected, and the remaining machine run with the compound engine. The vertical marine type machines consist of a single vertical steam cylinder, with compressor arranged alongside of it, both secured to a casting containing the condenser coils, which are made of copper, and behind this casting is another secured to it, containing the evaporator coils, the whole making a very compact and accessible design.

The vertical land type machine consists of a rectangular or circular cast-iron tank, with which is cast the frame carrying the compressor. Inside the rectangular tank are the condenser coils, and inside them again is a double tank, with insulation between, and the evaporator coils in the centre.

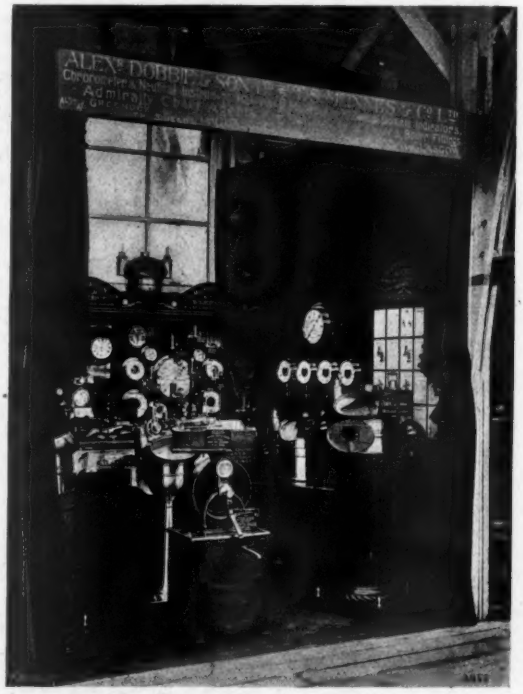
These machines require from one and a-half to seven brake horse-power to drive them, according to capacity, and, being fitted with fast and loose pulleys, may be driven by any existing power, such as steam, gas, petroleum, hot-air engines, water motors, or from existing shafting. The small machines may be driven by electric motor, gas engine, oil engine, steam engine, or by any other power available.

MESSRS. CROSSLEY BROS., LTD.

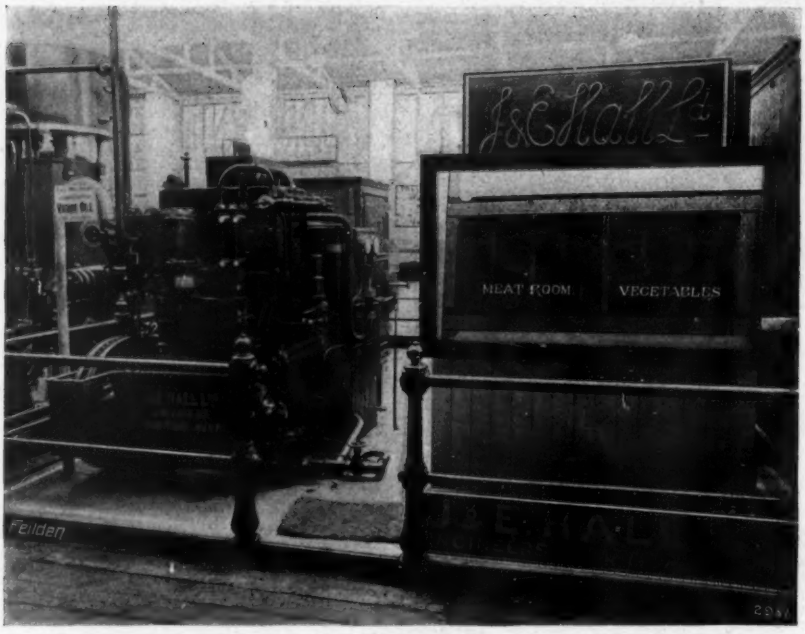
There was an extensive and excellent display of gas and oil engines by quite a number of manufacturers. Among them the exhibit of gas and oil engines by Messrs. Crossley Bros., Ltd., Manchester, was a notable one, as our illustrations will show. First there is type "H," the smallest size of horizontal gas engine, ¾ h.p. effective working load with a speed of 300 revolutions. This engine is fitted with flywheel, pulley, sensitive governing arrangement, and porcelain tube ignition, it takes up very little space and is very economical.

Next is type "L" gas engine, 5 h.p. effective, fitted with standard flywheel, pulley, porcelain tube ignition, and centrifugal governor. The governor of this engine is of the same elaborate type as is supplied with the largest engines made. The engine is fitted with the usual loose liner crank-shaft cut out of solid steel forging, and is in all respects built on the same lines as the bigger engines.

The third example is the standard type of medium-sized engines, type "O," being



THE STAND OF MESSRS. T. S. McINNES AND CO., LTD., AND MESSRS. ALEX. DOBBIE AND SON.



MESSRS. J. AND E. HALL'S EXHIBIT.

11 h.p. effective, and type "S," being 20 h p. effective.

Then there is a combination of gas engine and dynamo. The size of the engine in this case is the "PE," 18 h.p. effective easy working load, with a speed of 250 revolutions. This engine is fitted with an exceptionally heavy flywheel, 6 ft. 10½ ins. diameter by 5½ ins. wide, and owing to the great weight of this wheel it is necessary to support the shaft with an out-end bearing; the shaft also carrying balance weights to eliminate vibration. The dynamo is of the Thomson-Houston manufacture, and the plant has a capacity of about 11½ kilo-watts. The engine is a special type of high-speed sensitive electric lighting engine, and with this combination an absolutely steady light is guaranteed.

Type "UE" is a high-speed electric light engine, built on the same lines as the above "PE," but for engine only. It is assumed that the power to the dynamo is taken by belt from the flywheel, but the dynamo can be coupled to the end of the shaft, on the same lines as the "PE."

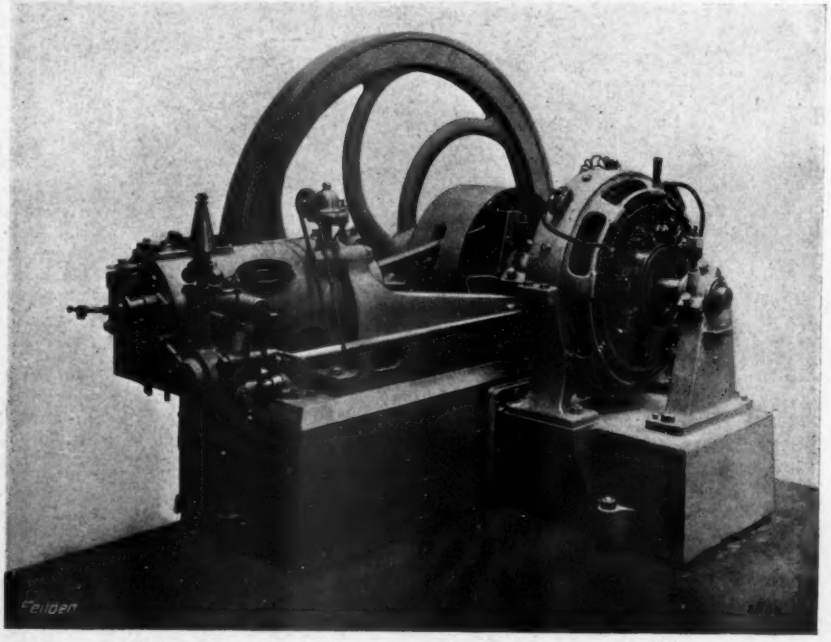
This "UE" engine is 41 h.p. effective easy working load, speed 220 revolutions, flywheel 8 ft. diameter. The makers claim for these oil engines that they are extremely economical, both at full or intermittent loads, very powerful, reliable, and easily understood.

THE CAMPBELL GAS ENGINE COMPANY, LTD.

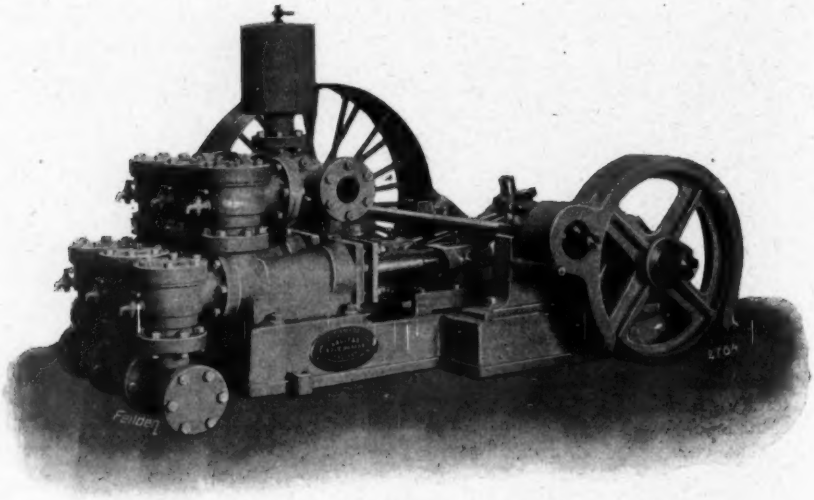
In the same section the Campbell Gas Engine Company, Ltd., Halifax, showed an interesting horizontal three-throw pump, with rams 4 ins. diameter by 9 ins. stroke. The pump crank-shaft is of the three-throw bent type, made of Siemens-Martin steel, working in adjustable gun-metal bearings. The connecting rods are of Siemens-

Martin steel, forged from the solid and finished bright all over. The crank-pin ends are fitted with adjustable gun-metal bearings, and at the slipper-guide end the connecting rod has an adjustable brass bush fitting the hardened steel gudgeon pins in the cross-head. The pump base-plate is of strong box section, and the pedestals for the crank shaft bearings are cast on it. The pedestals are fitted with strong cast-iron caps, with adjustable gun-metal bearings and lubricators. The cross-head slippers are of cast iron and of large area, and are attached direct to the pump rams. The pump barrels are made separately from each other, and also separately from the valve-boxes, each pump barrel being interchangeable with the other. They are made of close grain cold-blast cast iron, and constructed for a working pressure of up to 500 lbs. per square inch. The valve boxes are cast separately from the pump barrels, and each valve-box is separate from the other, and interchangeable with the other. The pump-gear wheels are of cast iron, with machine-cut teeth, and of the ratio of $4\frac{1}{2}$ to 1, so that the pump counter-shaft may run at a speed of $121\frac{1}{2}$ revolutions per minute. The counter-shaft is of steel, and runs in adjustable gun-metal bearings. The pump-rams are of cast iron: the pump-ram glands of cast iron, and bushed with gun metal. The suction and delivery pipes are each made in three separate parts, each part interchangeable with the other.

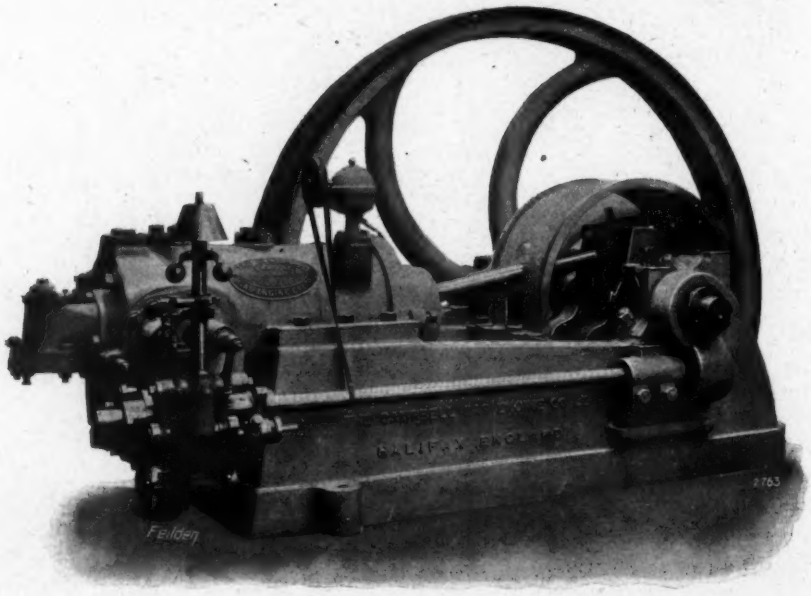
This firm showed a "Campbell" gas engine, capable of giving 16-h.p. brake or actual h.p. constant working load. The cylinder is 9 ins. diameter by 14 ins. stroke, bolted firmly to the bed and fitted with liner or working barrel of special hard cold blast-iron. The space between the liner and outside of cylinder forms the



MESSRS. CROSSLEY BROS.: COMBINED GAS ENGINE AND DYNAMO.

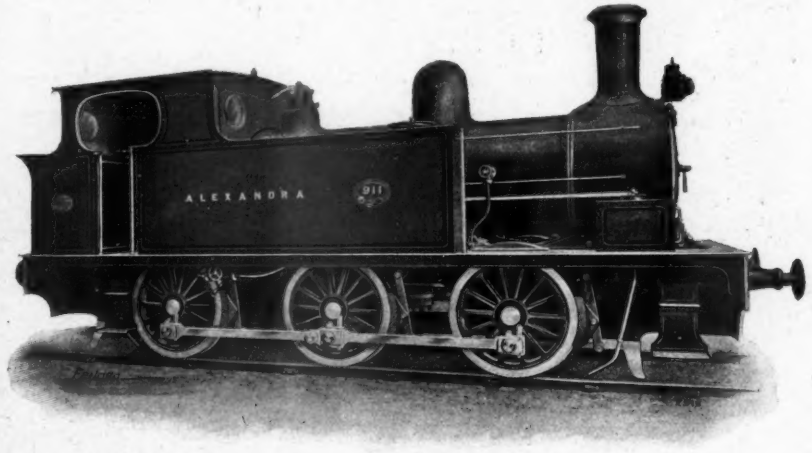


THE CAMPBELL GAS ENGINE CO.: HORIZONTAL THREE-THROW PUMP.



THE CAMPBELL GAS ENGINE CO.: 18-H.P. ELECTRIC LIGHTING GAS ENGINE.

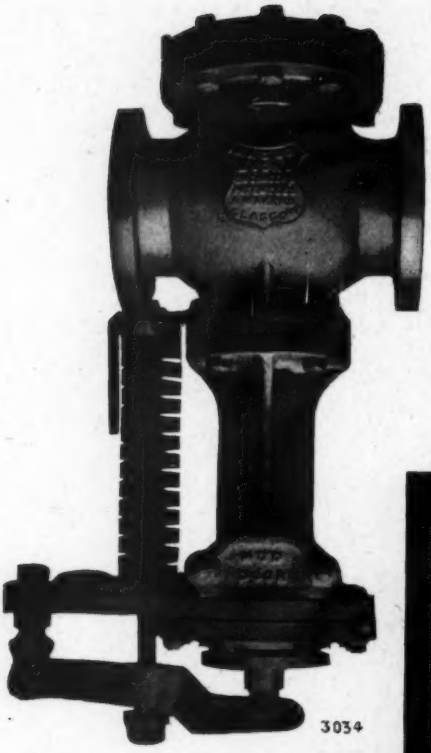
water-jacket, which keeps the cylinder cool by means of a constant circulation of water. The engine bed is a massive hollow casting, prolonged under the cylinder so as to reduce the overhang of cylinder to a minimum. This improvement gives a massive bed with a strong hold of the foundations, and prevents that vibration and loose working of engines on their foundations common with engines having long overhanging cylinders. The piston is of the bucket type, made of cold-blast iron of close grain, hard, and carefully fitted to the cylinder with spring rings, and suitably fastened to the connecting-rod, which is of Siemens-Martin steel, turned and polished all over, forged from the solid in one piece, and fitted with adjustable brasses at both ends. The crank-shaft also is of Siemens-Martin steel, forged from the solid, and running in gun-metal bearings, made adjustable, with ample wearing surfaces. The fly-wheel is of extra weight, in order to ensure steady running. It is 6 ft. 9 ins. diameter by 8 ins. broad on face; rim turned and polished; speed 230 revolutions per minute. The governor is of improved construction, very sensitive, and so arranged that changes in speed can be made without stopping the engine. The governors also control automatically the amount of gas consumed, and regulate the quantity to suit the work being done at any period. The lamp is of improved pattern for heating the ignition tube, allowing a powerful heat to be got rapidly for starting purposes, and when the engine is started the lamp flame is capable of being reduced. The anti-fluctuating gas-bag is made of cast iron. This apparatus makes it practically impossible for the engine to affect the steady flow of gas in the mains in a serious degree, and prevents any variation of pressure affecting the proper proportion of gas and air in the cylinder. The engine is, with the special porcelain ignition tube, guaranteed to last for six months.



MESSRS. ANDREW BARCLAY AND SONS: SIX-WHEEL COUPLED SIDE-TANK LOCOMOTIVE.

ANDREW BARCLAY, SONS & Co., Ltd, KILMARNOCK.

Inability to obtain a photograph deterred us from dealing with the above-mentioned firm's exhibit when the other locomotives were described. The illustration above serves to give a good idea of the general design of the mag-

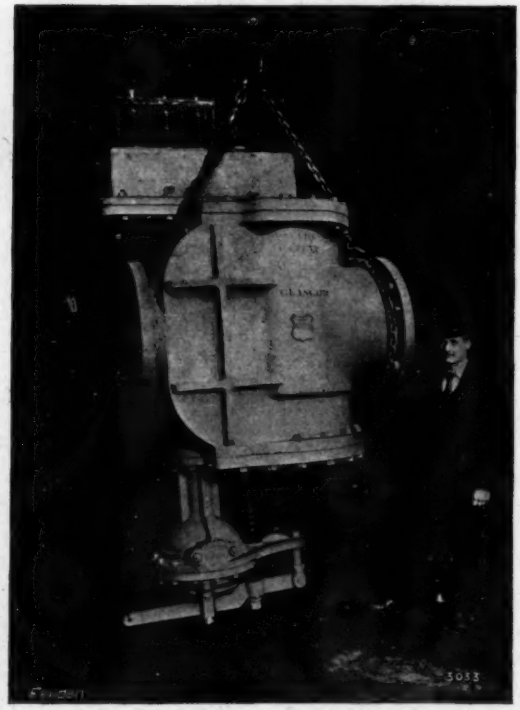


MESSRS. DAVID AULD AND SONS: STANDARD TYPE REDUCING VALVE.

nificent and highly finished inside cylinder, six wheels coupled side-tank locomotive, "Alexandra," constructed and exhibited by Messrs. Barclay, Sons & Co., Ltd., who have been engaged in building locomotives for the past fifty years. The engine, while not presenting any novel features, is sufficiently interesting in that it is a fine example of sound workmanship and neatness of design. One point, perhaps, may be mentioned which is somewhat exceptional, and that is the exceptionally strong framing, the mild steel side-plates of which are $1\frac{3}{8}$ ins. thick.

The following are the leading particulars :—

Cylinders ...	16-in. diameter, 24-in. stroke
Wheels...	4-ft. diameter
Tyres	3 ins. thick
Axle journals	$6\frac{3}{4}$-in. diameter
Boiler barrel, 4-ft. $0\frac{1}{8}$-in. diameter, 9 ft. $7\frac{5}{16}$ ins. long.	
Thickness of boiler shell	$\frac{9}{16}$ in.
do. smoke box tube plate...	$\frac{1}{2}$ in.
do. fire box tube plate (copper)	$\frac{13}{16}$ in.
do. brass tubes ...	11 to 13 B.W.G.
Heating surface	865 sq. ft.
Grate area	11·5 ,,
Working steam pressure ...	160 lbs. per sq. in.
Hydraulic test pressure ...	240 ,, ,,
Tank capacity	830 gallons
Bunker capacity	94 cubic ft.



MESSRS. DAVID AULD AND SONS: LARGE BORE REDUCING VALVE.

	Tons.	cwts.	qrs.
Weight in working order—leading wheels	12	15	0
do. do. driving do	13	12	0
do. do. trailing do.	12	8	0
Total ...	38	15	0

Tractive force, 128 lbs. for each lb. of pressure per sq. in. on piston.
Hauling power on the level ... ... 730 tons.
do. do. on a gradient of 1 in 80 320 ,,
Total wheel base ... ... 12 ft. 6 ins.

MESSRS. DAVID AULD & SONS,

of Whitevale Foundry, Rochester Street, Glasgow, had a number of their well-known reducing valves working in the Exhibition; amongst others may be mentioned a 9-in. reducing valve, reducing the pressure of steam from 150 or 160 lbs. to 100 lbs., for supplying reduced pressure steam to the engines in the stand of Messrs. Daniel Adamson & Co., Ltd., of Manchester; a 10-in. reducing valve, reducing the pressure of steam from 150 or 160 lbs. to 100 and 120 lbs. for a number of exhibitors in the Machinery Hall; one 2-in. reducing valve, at the rear end of the Penman boiler, for reducing the pressure of steam from 120 to 35 lbs., for supplying reduced pressure steam to the Bermaline Bakery; and a number of others were fitted throughout the Machinery Hall, and also in the restaurants in the grounds, for cooking, heating, etc.

The use of a reducing valve has become necessary through the great rise that has recently taken place in the working pressure of steam both for marine and land use, and David Auld & Sons were the first makers of reducing valves in this country; they have made them in all sizes, from ½-in. up to 24-in. bore, and some time ago they sent out the largest reducing valve for steam in the world, namely, a 24-in. reducing valve, while a number of 20-in. and 18-in. reducing valves are sent out every year.

As this type of reducing valve has no packed piston to retard the action of the reducing valve through setting up friction, it is specially suited for work where great accuracy in working is desired and, owing to its simplicity of construction requires very little repair.

MACHINERY APPLIANCES AND PROCESSES.

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

SALFORD CORPORATION.

DESCRIPTION OF EIGHT GENERATING SETS FOR THEIR ELECTRIC LIGHTING AND TRAMWAY SERVICE.

THE engines are constructed by Messrs. Browett, Lindley & Co., Ltd., Patricroft, and each is constructed to give 1,250 i.h.p. as a normal load, but is capable of withstanding an overload of 25 per cent. They run at a speed of 100 revolutions per minute and with a steam pressure of 140 lbs. to the square inch, and exhaust into a condenser having a 26-in. vacuum. The engines are of the three-crank vertical tandem type, the high-pressure cylinders are carried on the top of the low-pressure cylinders on polished steel pillars acting as distance pieces. Between the bottom covers of the high-pressure cylinders and the top covers of low-pressure cylinders, the distance is sufficient for the latter to be raised in order to renew the piston rings in the low-pressure cylinder when required. Each low-pressure cylinder is carried on the top of a cast-iron distance piece containing the wiper gland. These distance pieces also contain the bored guides for the crosshead slippers, and are securely bolted to the top of the engine frame. The frame is strongly ribbed and provided with hinged doors both at the front and at the back of the engine, to give easy access to the working parts of the engine; each frame weighs about 14 tons.

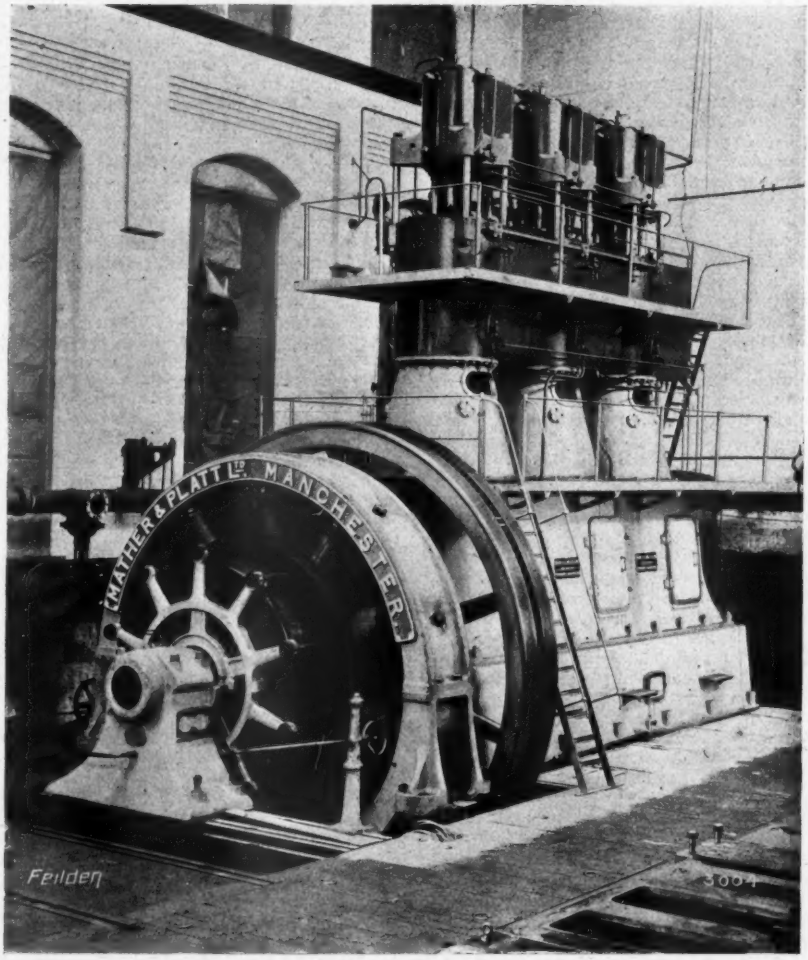
The base-plate of the engine is of very massive design and contains the four main bearings. The outer bearing next to the fly-wheel is 14-in. diameter by 2 ft. 8 ins. long; the other three bearings are 13 ins. diameter. The bearings are of gun-metal, lined with Dewrance's white-metal. The crank-shaft is of the built-up type, the crank-pins are 13 ins. diameter, and a 4-in. diameter hole is bored right through the shaft and also through the crank-pins. The ends of these holes are plugged up and the holes act as the reservoir and conductor for the oil supply to the main bearings and crank-pins. The eccentric clips are of cast-iron, working on cast-iron sheaves.

The whole of the working parts of the engine are under forced lubrication, the oil being forced under pressure into each bearing by means of two simple valveless pumps, driven by eccentrics on the engine shaft. Each pump is fitted with a filter through which the oil is pumped and which ensures clean oil being supplied to the bearings. A pressure gauge is fitted outside the frame which shows the pressure of the oil on the bearings.

The governor is of the high-speed centrifugal type, and is contained in a hood carried on the engine frame and close to the starting valve. The governor is under forced lubrication throughout, and runs at a speed of 400 revolutions per minute. The governor gear is driven by a chain made by Messrs. Hans Renold, and a spray of oil is always playing on the chain whilst working to ensure efficient lubrication.

The connecting rods are of mild steel. The crosshead pins are case-hardened and are forced into the connecting rods by hydraulic pressure. The crossheads are of the "marine" type and are cottered to the piston rods. The slippers are of cast-iron and work under forced lubrication. The piston rods are of ·4 carbon steel, and are ground up perfectly cylindrical.

The high-pressure cylinders are 15 ins. in diameter by 30-in. stroke, and are fitted with loose liners. Both the cylinders and the cylinder covers are steam-jacketed with steam at boiler pressure. The high-pressure piston is of cast-iron fitted with plain "Ramsbottom" rings. The bottom of the high-pressure cylinders and the top of the low-



GENERATING SET FOR THE SALFORD CORPORATION:
ENGINES BY MESSRS. BROWETT, LINDLEY AND CO., LTD.: DYNAMOS BY MESSRS. MATHER AND PLATT, LTD.

pressure cylinders are fitted with packings of the United States make, and are suitable for working with steam at a temperature of 100 degs. superheat. The valves of the high-pressure cylinders are of the piston type; the valve-boxes are fitted with hard cast-iron liners forced in by hydraulic pressure.

The low-pressure cylinders are 32½ins. in diameter by 30-in. stroke, and, like the high-pressure cylinders, are steam-jacketed. The low-pressure valves are of the balanced slide-valve type; the clearances in the low-pressure cylinders are extremely small. Both the high-pressure and low-pressure valves are driven from eccentrics on the engine

shaft. The low-pressure pistons are of stamped steel and are provided with plain "Ramsbottom" rings.

The speed of the engines is controlled by means of the governor acting on a throttle valve supplying steam to each high-pressure cylinder. The overload is obtained by an auxiliary throttle-valve worked from the main governor, which admits high-pressure steam to the low-pressure cylinders when necessary. A knock-off gear is provided for high and low speeds, which, in case of need, disconnects the throttle-valve from the governor and allows it to drop on its seat, thus shutting the engine down immediately should any accident happen to the governor.

All the handles of the drain cocks, speeder gear, lubrication and stop valves are brought to one end of the engine frame, and are within easy reach of the attendant. The vertical rod of the stop valve is provided with a hand-wheel on each platform.

The flywheels are 16 ft. in diameter, and each weighs 18 tons. They are made in halves and are bolted and cottered together on the rim, and also cottered on the boss, on which heavy steel hoops are shrunk. The wheels are secured to the crank-shaft by four steel keys.

From tests made at Messrs. Browett, Lindley & Co.'s works the drop in speed from no load to full load was 2½ revolutions; the temporary run up when all load was thrown off was 7 revolutions.

Each engine has its own cast-iron separator carried on a bracket on the engine house wall, the separator being provided with water-level gauge fittings and protector glass.

The cylinders are completely covered with asbestos composition and lagged with planished steel.

The dynamos have been constructed by Messrs. Mather & Platt, Ltd., of Salford Iron Works, and are direct coupled to the boss on the engine flywheels. The dynamos are of very massive design. The yoke-ring is of cast-steel of high magnetic quality, and is made in halves for convenience in handling. The pole-rings are not cast in one with the ring, but are separate and bolted to the ring with two bolts; the shoes are cast with the pole-pieces, and the spools for the field windings are slipped over the latter before they are bolted up. This combination allows for the easy removal of a coil without the necessity of disturbing the yoke-ring or the armature.

The armature is of the drum type, with a slotted core. The thin soft iron sheets of the core are punched out and built up on a double spider. This latter has one half-coupling cast with it, so that no stress passes through the shaft. The well-insulated copper strip windings are entirely embedded in the slots of the core.

As the Salford Electricity Works have to supply current for traction as well as for lighting, the dynamos are constructed to work either as compound or shunt. The normal output of the dynamo as a compound machine is 775 kilo-watts at 525 volts for supplying power to the tramways, and as shunt machine is 775 kilo-watts at 480 volts for lighting; the normal working load can, however, be safely increased to 1000 kilo-watts should necessity arise. The dynamo has ten poles, and the total weight is just over 50 tons, the armature alone weighing 25 tons. As a result of tests already made the efficiency of the dynamos comes out at rather over 95 per cent. Of the 5 per cent. loss, hysteresis and eddy currents account for 2·27 per cent., C^2R losses for 2·57 per cent., and friction loss for 0·16 per cent.

Messrs. Lacey, Clirehugh & Sillar, of Westminster and Manchester, are the consulting engineers to the Salford Corporation.

We hope to be able to publish full working drawings of these interesting sets in our next issue.

H.M.S. "BEDFORD."

THIS first-class cruiser, which is a sister ship to the *Essex*, is one of the "County" class, and forms the subject of the presentation plate this month.

She was recently launched by the Fairfield Shipbuilding and Engineering Company, Limited, and is a vessel of 9,800 tons normal displacement and 22,000 indicated horse-power.

The *Bedford* has a length of 440 ft. and a breadth of 66 ft., her normal draught being 24 ft 6 ins., and her normal freeboard amidship 19 ft. She will steam 23 knots, and has a coal capacity of 800 tons. The cost of the vessel will be £725,000.

There is side armour of 4 ins. in thickness, thinned down at the bow to 2 ins. There are armour bulkheads at the after end of the belt. Of the two protective decks, the main has a thickness of 1½ in., and the lower of ¾ in. The main engines are of the four-cylinder triple expansion type, and each of the two sets are designed to develop 11,000 indicated horse-power. The boilers are of the water-tube Belleville type, the safety valves being arranged for a pressure of 300 lb. per sq. in.

Each set of engines is placed in a separate engine room, divided by a longitudinal water-tight bulkhead extending the entire length

of the machinery space. Each engine-room is exactly similar to the other, but is quite independent. The high and intermediate pressure cylinders have a diameter of 37 ins. and 60 ins. respectively, that of the low-pressure cylinders being 69 ins. All have a stroke of 42 ins. The former have piston valves of the inside type, with approved adjustable packing rings; while the low-pressure cylinders are fitted with treble-ported flat slide valves on their sides, having a special type of relief frame to relieve them of steam pressure. The weight of all the valves is suitably balanced so as to reduce the strain on the valve gear as much as possible. To increase the stability of the cylinders in the event of ramming, strong struts are fitted between the high-pressure cylinder and the forward structure of the vessel, as well as transversely between the respective cylinders in each engine-room. The valve gear is of double eccentric link-motion type, and is moved by a double cylinder engine. Each of the reversing levers is provided with screw gear, so that the valves of each cylinder may be linked up separately. The crank shafts are hollow, and each consists of two interchangeable pieces, 18 ins. in diameter at the journals. The crank arms are cut away as much as possible to secure greater lightness and for convenience in fitting the centrifugal lubricators. The thrust shaft and propeller shafting are also hollow, the shafting being 17 ins. in diameter inboard and 19½ ins. in diameter outside the ship. The propellers are three-bladed, working inwards, having a diameter of 16 ft. 3 ins., the bosses being of gun-metal and the blades of manganese bronze. Tail pieces and guards have been provided forward and aft of the propellers to prevent eddies. The four main condensers are of cast brass, and have a total cooling surface of 23,000 sq. ft.

The water is supplied by four large Allen's circulating pumps, each driven by an independent engine. Each of the pumps, with steam of 200 lbs. pressure, is capable of d scharging 1,200 tons of water per hour from the bilge. The engines by which they are driven work at a speed of 300 revolutions per minute. The combined cooling surface of the two auxiliary condensers is 3,150 sq. ft., their tube casings being of rolled brass sheets. Another feature of the auxiliary machinery consists of a double-cylinder turning engine, which, by means of a set of compound worm-gearing, is capable of turning the main engines completely round in eight minutes, with a steam pressure of 200 lbs. A hand-gear has also been provided for the same purpose. There are two steering engines, by Napier Bros. & Co.

A set of special pumps take the water from the hotwell tanks and discharge through the filters to the feed tanks. In each of the engine-rooms two steam fans of 5 ft. diameter are provided for ventilation. There are also twelve ventilating fans in the boiler-rooms, with a diameter of 6 ft. 9 ins. Four large sets of condensing engines and dynamos supply internal electric lighting, searchlights, &c. The air-compressing machinery for charging the torpedoes comprises two complete sets of single air-compressing engines and pumps, and four sets of air-reservoir tubes, with separators and charging columns. A small ice-making machine is fitted forward. There are also air-blowing engines for supplying air to the furnaces, and six ash-hoisting engines, with brake apparatus and automatic stop-gear.

The steam is generated in 31 Belleville boilers of the economiser type, placed in three separate water-tight compartments. The tubes are of 4½ ins. external diameter, and are of cold, solid-drawn steel. The total heating-surface of the boilers is 33,100 sq. ft., and of the economisers 17,200 sq. ft., making a total of 50,300 sq. ft. In each boiler-room is a double-acting feed pump of the Weir type. The main steam supply is conveyed by four lines of steel steam-pipes.

The armament includes 14 weapons of 6-in. calibre, firing 100-lb. projectiles, and developing an initial energy of 53·40 ft. tons when cordite is used. Two of the guns are mounted in a turret in the forecastle, a system introduced for the first time in cruisers. There are two 6-in. guns in a two-storeyed casemate on the port and starboard quarters, forward and aft, while in the waist of the ship there is one 6-in. gun on either broadside. There are also 13 smaller guns. The lines of the *Bedford* are very fine, so as to secure the highest possible speed, and this fact has necessitated a special arrangement of the boilers.

THE INVERMAY HOUSE ELECTRIC INSTALLATION.

THE electric installation which has been completed for Mr. J. M. Fraser, managing director of Macdonald & Fraser, Ltd., at Invermay House, near Perth, is one of those which can be suitably made and inexpensively maintained at many Scotch places which have the advantage of a stream and a high fall. All along the mountain side

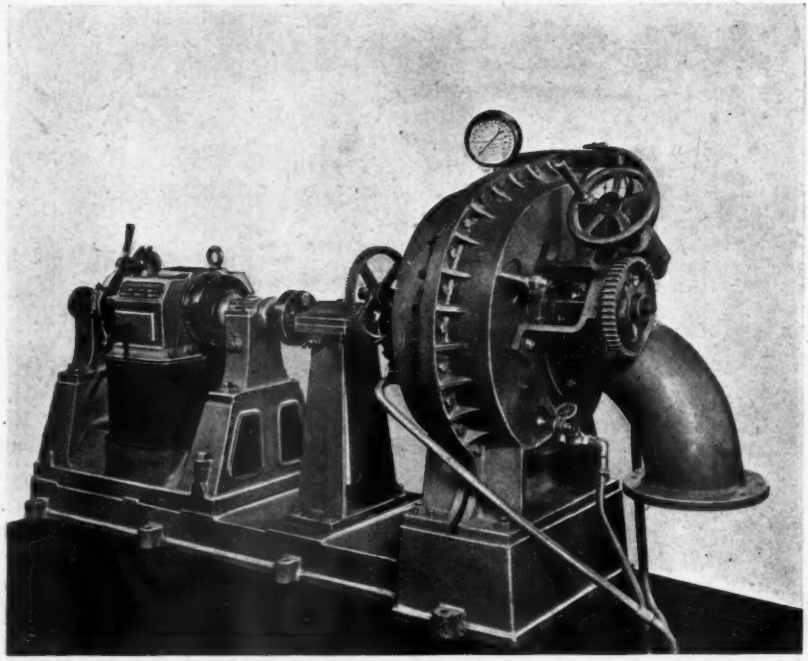
there arenumerous small valleys, each having its own stream, and in many cases these streams descend from a high level to a low level in short distances, enabling the fall of water to be utilised at small expense. In such cases it is only necessary to build a dam across the stream and thus form a reservoir of water, and from this dam lead a pipe to conduct the water to the power-house, built at a lower level.

The installation which has been made for Mr. Fraser is of the above description. The pond or reservoir for containing the water has been formed by building a dam across the adjacent stream. From this reservoir a cast-iron pipe has been laid to the power-house, the length of the pipe being 2540 ft., and its diameter 9 ins. Joined on to this pipe is another of 8 ins. diameter and 160 ft. long, made of riveted steel, and this joins on to the inlet flange of the turbine; the total length of pipe track being thus 900 yds. In this length, or rather from the surface of the pond to the tail race, the fall is 200 ft.

The turbine house is built on concrete columns, and is thatched with reed, which grows on the banks of the Tay, and presents, as will be seen in the photograph, a pretty appearance. The wheel is of the 10-in. single type, coupled direct to a Parker dynamo, giving an output of 60 amps. and 175 volts, suitable for charging the accumulator from which the lamps receive the current. The turbine is so placed that there is a fall from it of 15 ft. to the tail race. So that there is in all a fall of 185 ft. to the turbines and 15 ft. of suction, making a total of 200 ft. of fall. The turbine gives out about 12 brake h.p., and its speed is 1,000 revs. per minute. The pond from which it receives the supply of water has been well stocked with fish, and therefore serves as an artificial fish pond as well as a water-power reservoir. The power-house is about 150 yds. from the mansion house.

The turbine wheel itself is of considerable

INVERMAY POWER-HOUSE.



INVERMAY HOUSE ELECTRIC INSTALLATION: TURBINE DESIGNED BY MR. R. G MORTON.

interest, as designed by Mr. R. G. Morton, of Errol. To illustrate its construction we give drawings of the double-suction type shown in cross section (Fig. 1), and in longitudinal section (Fig. 2). The several parts are marked, and by these the construction will be easily understood.

In Fig. 2 will be seen a section of the revolving wheel and its buckets, the wheel being 1 ft. 10 ins. diameter, and each bucket $4\frac{3}{4}$ ins. wide. The wheel is of cast-iron and the buckets of the same material. The wheel is supported by and keyed on to a shaft 3 ins. diameter, which is carrried on stuffing-boxes fitted on the sides of the suction bends. Gunmetal liners are fitted in the stuffing-boxes, and on these the shaft runs.

The water enters the pipe by the bell-mouthed intake, and fills the casing or flume, which is large to obviate any formation of small whirlpool currents.

The guide blade chamber is shown in Fig. 1. The guide blades are not fitted round the outside of the whole circumference of the wheel, but only at two portions opposite each other, as shown in figure. Round the outside of this is fitted a gunmetal sluice ring, which in this case is provided with a rack in the middle, and this rack is actuated by a pinion, shown as sluice ring pinion in side view, Fig. 1, and in section, Fig. 2. When this pinion is rotated in the direction of the arrow it moves the sluice ring in the same direction on opposite sides of the wheel, and when one space of the guide blade chamber is shut off on one side a corresponding space is shut off on the other side. It is thus the spaces are shut off in pairs.

It will be noticed that there is no choking of the water. The quantity allowed to enter is regulated, and the water is allowed to enter a small number of the spaces of the guide blades in the same efficient manner as it enters all of them when the sluice ring is fully open. This is a decided advantage in this class of turbine.

It will be noticed that the water is directed

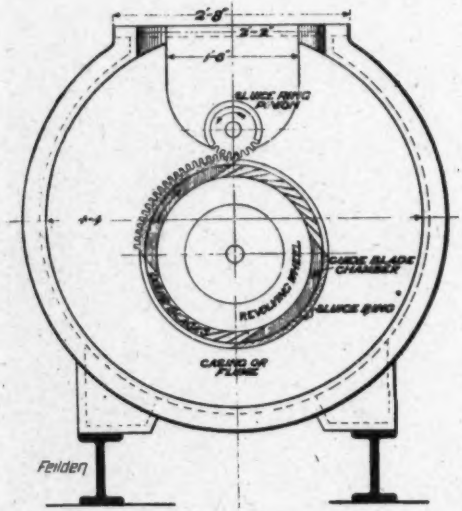


FIG. 1.

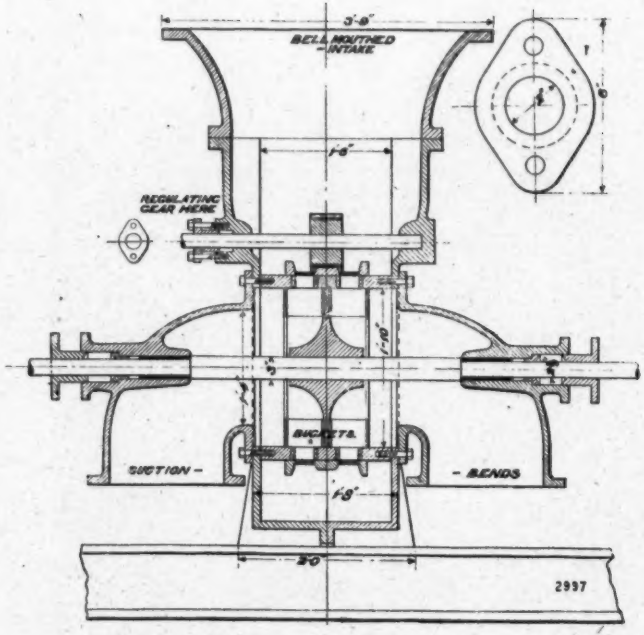


FIG. 2.

INVERMAY HOUSE ELECTRIC INSTALLATION: DETAILS OF TURBINE.

at a definite angle to play on the guide blades. When it has impinged on them and flows through it is guided to the side into the suction bend by the sides of the wheel.

But the buckets are very simple, being straight through and not shaped so as to be acted on by the water while it is flowing round into the suction bend after the manner of some American turbines.

The proof that the whole energy has been taken out of the water before it flows out into the suction bend can only be shown by the brake trials.

The account and description of the installation would be incomplete without the details of the electric lighting part of it.

As has been already pointed out, the distance from the power-house to the accumulators is 150 yards, and the cable through which the current is conveyed from the power-house to the accumulator-house is the well-known Glover's diatrine lead, covered and armoured $\frac{18}{16}$ s.

The dynamo is by Messrs. Thomas Parker, Ltd., of Wolverhampton, and has an output at full load of 60 amps. at 170 volts, the revolutions being 1,000 per minute, the high voltage used being suitable for charging the accumulators. The voltage of the accumulators as they supply the lamps is 100.

The accumulators are by Messrs. Pritchetts and Gold, of Feltham, Middlesex, and they are capable of supplying a current of 63 amps. for a period of six hours.

The wiring of the house has been done by Messrs. Middleton and Townsend's. In doing this work the firm's special screwed iron conduit system, with their patent joints, was adopted. The wiring is carried out in the distributing system of four-ampère circuits, in which no circuit carries more than eight lights.

The whole installation, and the light obtained from it, is an excellent example of what can be made of an exceedingly small stream in the Highlands.

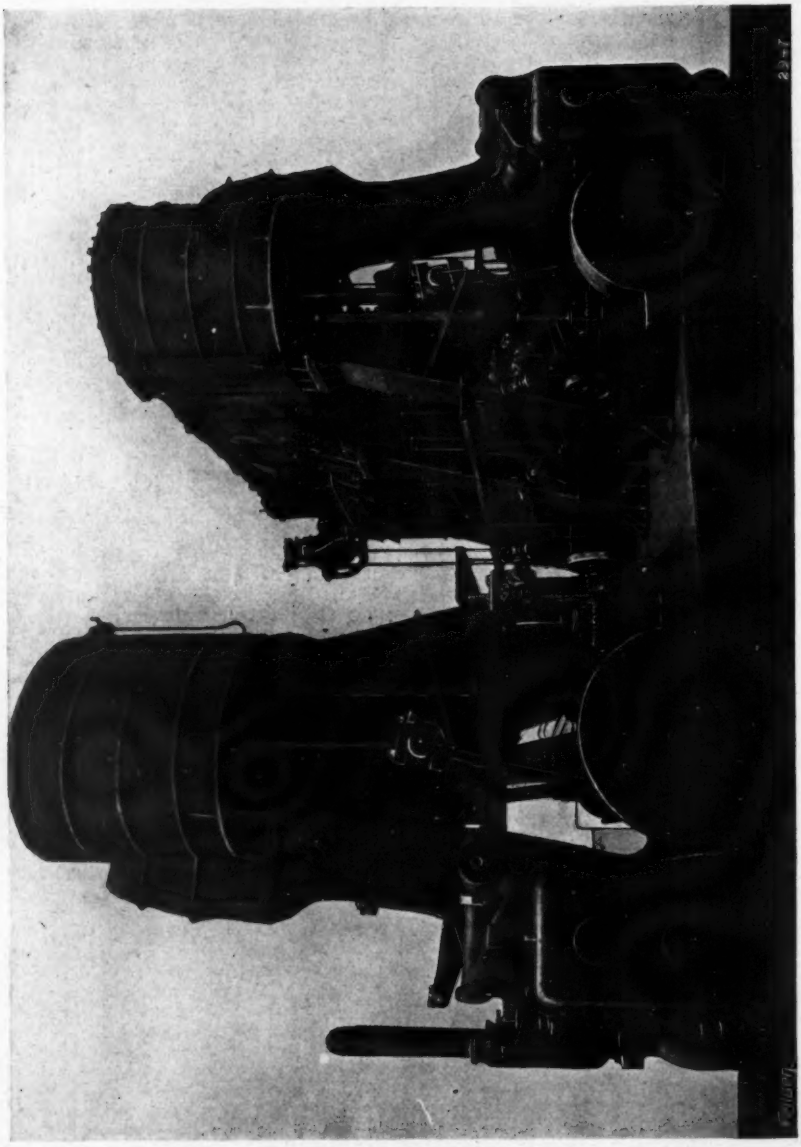
THE NEW AMERICAN LINER "HAVERFORD."

THE large twin-screw steamer *Haverford*, built by Messrs. John Brown & Co., Ltd., of Clydebank, for the International Navigation Company of the United States, is an example of a type of vessel which has of recent years found great favour with Atlantic passengers. She is of the "intermediate" class, in which the claims of large cargo-carrying capacity exceed those of speed, and yet in which sufficient speed is maintained to make it worth while to provide extensive passenger accommodation. Many passengers now prefer to travel by these vessels rather than by the faster liners.

The main propelling machinery of the *Haverford* consists of two sets of vertical triple-expansion engines of the usual inverted marine type, each cylinder driving a separate crank. The diameter of the h.p. cylinder in each set is 29 ins., the diameter of the i.p. 46½ ins., and the diameter of the l.p. cylinders in each set is 75 ins., with a stroke of 4 ft. 3 ins. The slide valves are of the piston type for the h.p., and of the flat-faced type for the i.p. and l.p. The valve gear is of the double eccentric, double bar link motion. The air pumps are driven by levers off the crosshead of the i.p. cylinders. A direct-acting steam reversing engine is fitted to each set of engines, and the levers of the reversing shaft are fitted with screw gear to admit of the adjustment of cut-off being made in one cylinder independently of any of the other cylinders. The cylinders, liners covers, front and back columns, condensers, and sole plates are all of cast iron, the condensers forming part of the main engine framing. All the shafting is of steel, and each crank shaft is of the built type, in three interchangeable pieces. The main bearings, thrust shoes, and tunnel blocks are all lined with white metal. The propellers are four-bladed, the bosses are made of cast iron, and the blades of manganese bronze.

The auxiliary machinery consists of two centrifugal pumps for circulating the water through the main condensers; two vertical simple pumps with float gear, capable of feeding the boilers when working at full power; two ballast pumps; one sanitary and one fresh-water pump; and a donkey boiler feed pump. There are also a feed heater and filter and a very complete distilling plant. An Aspinall governor is fitted to each engine.

For the generation of steam there are two double-ended and two single-ended boilers. The double-ended boilers are 16 ft. 8 ins. mean diameter by 19 ft. long, and the single-ended boilers are 16 ft. 8 ins. mean diameter by 11 ft. long. Each of the double-ended boilers has eight furnaces, and the single-ended boilers have four furnaces, being 24 in all. These furnaces are of the Morison suspension type, 3 ft. 4½ ins. inside diameter, with the back ends made on the Gourlay-Stephen principle, whereby a defective furnace can be taken out of the boiler without disturbing any other part of it. The end plates



VERTICAL TRIPLE-EXPANSION ENGINES OF THE S.S. "HAVERFORD."

of the boilers are all flanged inwards to meet the shell and the furnaces.

Each opposite pair of furnaces in the double-ended boilers has a common combustion chamber, and in the case of the single-ended boilers each furnace has a separate combustion chamber. The combustion chambers are all securely stayed to the boiler shell and ends. The combustion chamber tops in the single-ended boilers are supported by girders in the usual way, while those in the double-ended boilers are supported by stays attached to the shell of the boiler. The end circumferential seams are double riveted, and the middle circumferential seams are treble riveted. The double butt-strap longitudinal seams are also treble riveted with five rivets per pitch. The cross seams in the end plates are all double riveted, and all the rivet holes were drilled after the plates had been bent and flanged and fitted together in place, after which they were taken apart and the burrs cleaned off the rivet holes.

The boiler tubes are all of iron, 7 ft. 5 ins. long between the tube-plates and $3\frac{1}{4}$ ins. external diameter. The common tubes are No. 7 I.W.G. thick, and the stay tubes are $\frac{1}{2}$ in., $\frac{5}{16}$ in., and $\frac{3}{8}$ in. thick, to suit their respective loads. The common tubes have the front ends swelled $\frac{1}{16}$ larger in diameter than the back end, and the stay tubes have been staved up in a hydraulic press till the thickness at the screwed ends is the same at the bottom of the thread as the body of the tube. There is 11 ins. clear space between the nests of tubes for access for cleaning. The boilers work under natural draught at a working pressure of 160 lbs. per sq. in.

These boilers are supplied by John Brown & Co., Ltd., who also make all the machinery for the vessels they construct.

The dimensions of the *Haverford* are as follows:—Length between perpendiculars, 530 ft.; breadth, 59 ft.; depth, moulded to upper deck, 39 ft.; and the gross tonnage is about 11,500 tons. The vessel has been built to Lloyd's highest classification, and has been additionally strengthened against the heavy weather of the North Atlantic. There are ten watertight bulkheads, so arranged that flotation may be maintained with any two compartments flooded. The bunkers are of ample capacity, and are arranged so as to protect the boilers should the vessel be used for transport service in time of war.

The cargo holds occupy the whole of the ship below the upper deck, except the portions required for machinery and bunkers and the store-rooms in the peaks.

The cabin accommodation is entirely above the shelter deck, and is placed in a bridge-house about 150 ft. long, extending the full width of the ship. There are large and airy state-rooms for 150 passengers along the sides, and a handsome dining-saloon at the forward end is capable of seating 112 persons.

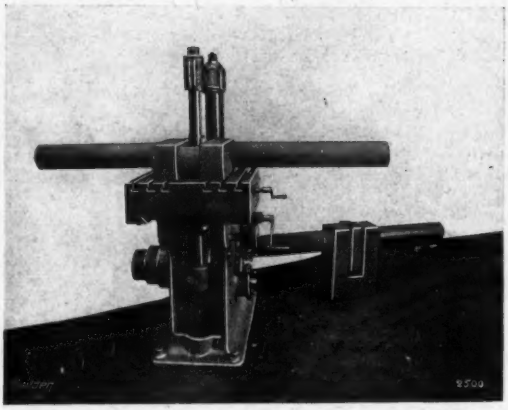
Overhead is the cabin passengers' promenade, upon which are placed the officers and captain's rooms, the entrance hall, and ladies' sitting-room, in a house at the forward end. At the after end, abreast of the engine casing, is another entrance lobby, communicating with a large and comfortable smoking-room on the starboard side and a handsomely finished library on the port side. Over these houses come the boat decks, and the wheel-house and navigation bridge, the latter being well protected by a steel bulwark.

In order to enhance the safety of the ship and ensure sufficient immersion of the

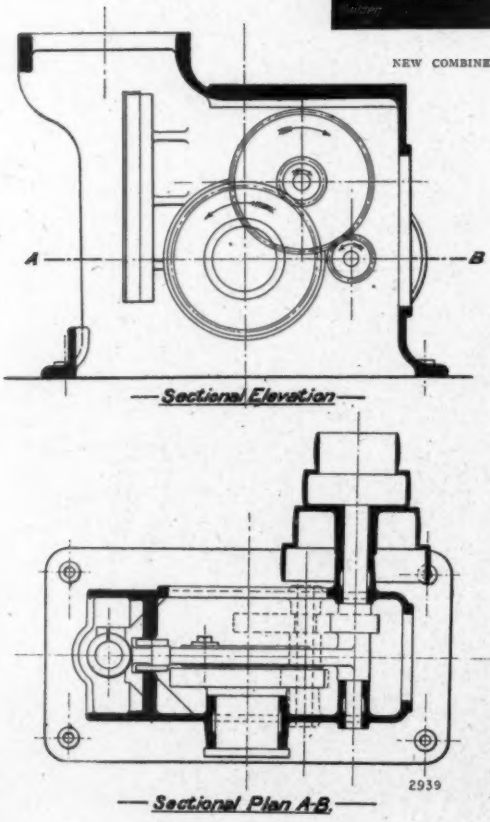
NEW COMBINED KEYSEATING AND SLOTTING MACHINE.

propellers when crossing in light trim, deep ballast tanks are provided in two of the holds extending to the lower deck; these, with the usual water ballast contained in the cellular double bottom, can give a total quantity of about 4,000 tons of water ballast.

A sister ship of the *Haverford*, to be called the *Merion*, is also being built by Messrs. John Brown & Co., Ltd.



NEW COMBINED KEYSEATING AND SLOTTING MACHINE.

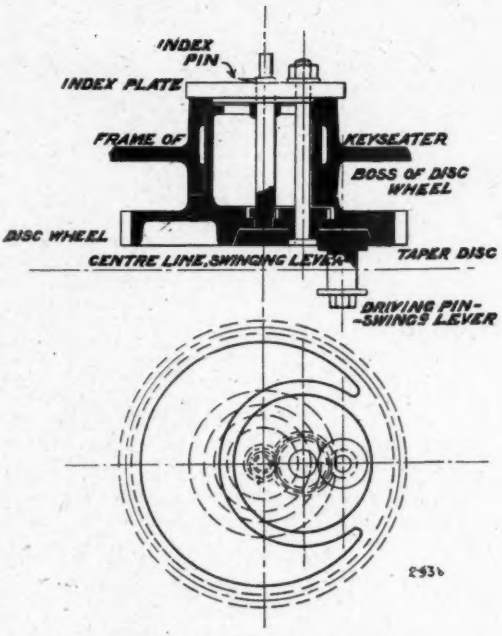


SECTIONS OF NEW KEYSEATER.

A NEW COMBINED KEYSEATING AND SLOTTING MACHINE.

THE frame of the combined Keyseating and Slotting Machine, illustrated on pages 479-81, consists of a single casting of the box pattern with a broad base, by means of which great rigidity and freedom from vibration are ensured. The work-table has a 12-in. power-feed in either direction longitudinally, and a short hand-feed transversely. The driving is effected from a four-step cone at the back of the machine, by means of compound gearing through a slotted lever and disc wheel, to a slide fitted at the front. This slide is provided with a split boss, into which the lower portion of the tool-bar is fixed, which latter has a quick return motion on the up-stroke. The cutting tools retain their standard size throughout a prolonged use of the machine, as the grinding required affects only the cutting face. They can be replaced, however, at a small cost, as they are of very simple construction. The tool in use is fitted into the lower part of the bar, and by a very ingenious device it automatically relieves itself on the up-stroke. The feed-motion is given at the top of the up-stroke, and

can be adjusted to any degree of fineness by turning the small handle at the top of the slotted lever on the side of the machine. The full feed corresponds to a ¼-in. travel of the bar. The adjusting of the stroke takes place from the disc on the side of the machine, provided with an index ranging from 1 in. to 15 ins. By means of the hind-bar the work can be taken out with the greatest ease, without the removal of the tool or the bar being required, and by this arrangement, of course, both labour and time are saved; and the quantity of work that can be done within a given period without any extra exertion is one of the salient features of the machine, among which must be mentioned also the advantages it possesses over the ordinary types of slotting machines in consequence of the rigidity of the plain bar, fitted with tools of the simplest construction, and requiring but little dressing, which suffices for doing ordinary slotting work. The supporting arm for the upper end of the tool-bar is carried on a column fixed on the top of the machine, and can be secured at any height on it best fitted for the depth of the job to be done at the time. The column has two definite positions corresponding to the two holes in the supporting arm. In our illustration the column is seen in the outer position; but in case the rim of the wheel to be slotted should foul in this position, the column is shifted into the inner position and brought inside the rim of the wheel, a simple but effective arrangement which permits the slotting of wheels of almost any diameter. The machine is suitable for cutting of key-seats of from ¼ in. to 1½ in. in width, and holes of 1 in. in diameter and upwards; and it is especially well adapted for finishing the sides of slab cranks, which can be done in less than half the time required for doing it on the lathe. There is, however, scarcely any kind of work that can be done with an ordinary shaping machine which may not be done equally well, and even better, in this combined key-seating and slotting machine. Among the accessories furnished to the purchaser, together with the necessary tool-bars for key-seating purposes, is a complete set of tools, a plain bar for ordinary work, and a counter-shaft with hangers, cone, and suitable pulleys. The makers are Messrs. Pollock, Whyte & Waddel, owners of the "Globe" Gas and Oil Engine Works, Johnstone, N.B.



DETAILS OF DISC WHEEL FOR KEYSEATER.

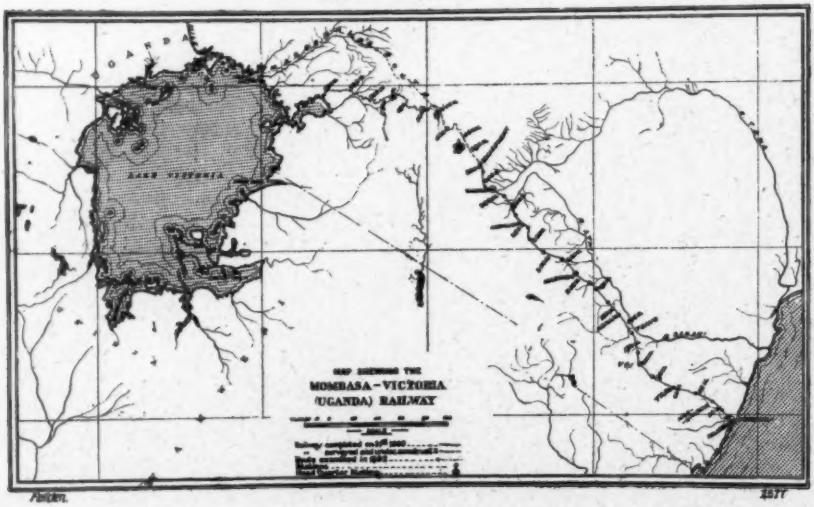
Should not our Industries be Protected?

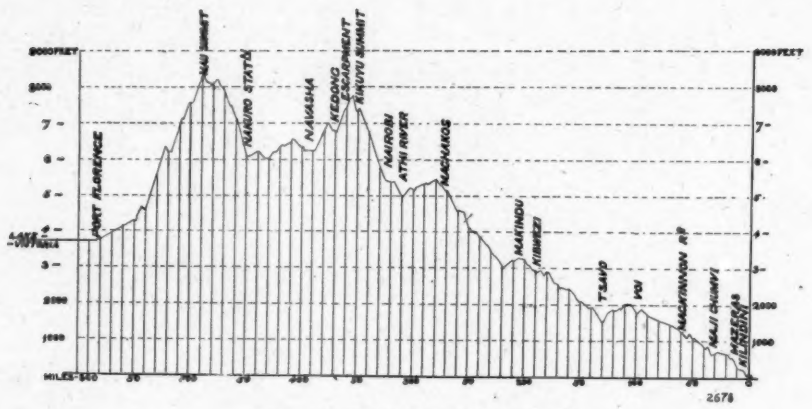
THIS vitally important question will undoubtedly agitate the minds of all thoughtful men of this nation in the early future. Our present fiscal arrangements, so competent experts say, will either keep this country in the forefront or be fraught with national disaster. Which is it to be? Opinions are strongly divided. We direct attention to our first leader on page 407 of this issue, and solicit the co-operation of our readers. Correspondence cordially invited.

THE UGANDA RAILWAY.

OF all the railways rapidly multiplying in Africa at present the Mombasa-Victoria Lake Railway, as was its original title, is perhaps the most important, if we except the great artery that sooner or later will cross Africa from south to north and unite Egypt with the great South African Empire. One of the most important reasons for the building of this line from the Indian Ocean to the Victoria Nyanza is intimated by its present name of Uganda Railway, taken from that of the important territory on the north and west of the Victoria Lake, which this line is intended to open up to European commercial enterprise. All the great European explorers who visited that country, from Speke and Grant in 1860, to Stanley, Felkin, and Emin Pasha, have borne testimony to its fertility, its beautiful climate rendering it quite suitable for European settlers, and its many important products of export, such as timber, fibre, cotton, rubber, and ivory. Great Britain, having obtained control over Uganda and its people, and thus having become morally responsible, so to say, for aiding the latter to rise higher in the state of civilisation and to become the nucleus around which the gradual transformation of the native population from a condition of savagery to that of husbandry and the higher stages of civilisation may take place, has the duty not to relinquish but to increase her hold in Central Africa. And it is for this purpose, as Lord Salisbury pointed out in the House of Lords when the railway scheme came under discussion, that the building of the line from Mombasa was absolutely necessary. Mr. Chamberlain Mr. Goschen, and other keen-sighted statesmen, fully shared Lord Salisbury's opinion and tried to impress their followers with the fact above-mentioned as well as with the great possibilities that would result from rendering easy the transport of the products of Uganda and the intervening regions to the sea-shore.

The Uganda Railway, of which the first sod was cut on December 11th, 1895 starts from the island of Mombasa on the south-east coast of Africa, and will have its terminus at Port Florence on the Victoria Nyanza, covering a total distance of 580 miles. On Christmas Day last year, the completion of 490 miles of track was reported, so that there remained at the beginning of the present year only 90 miles to be built. Leaving the island, the track, having a width of one metre (3·38 ft.), passes over





THE UGANDA RAILWAY: PROFILE OF GRADIENTS.

Salisbury Bridge, a handsome iron structure, formerly known as Macupa Bridge, of which our engraving (Fig. 2) gives a view taken from the island and looking towards the mainland. It is built on the "trestle" system, and rests on iron pillars sunk deep into the ocean bed, the platform being raised sufficiently above high-water level to be no obstacle to navigation. The actual eastern terminus of the line is Kilindini (Fig. 2),

FIG. 1.—THE UGANDA RAILWAY: INCLINE NO. 1. NO CARRIERS USED ON THIS GRADE, 1 IN 7.

FIG. 2.—THE UGANDA RAILWAY: SALISBURY BRIDGE, ORIGINALLY AND COMMONLY KNOWN AS MACUPA BRIDGE LOOKING TOWARDS MAINLAND.

FIG. 3.—THE UGANDA RAILWAY: KILINDINI ON THE MAINLAND FROM MOMBASA; THE BEACH, SHOWING COAL BIN, RATION SHED (ON LEFT), AND KILINDINI HOUSE.

which has an excellent natural harbour, although much had to be done to transform the place so as to render it suitable for landing stores and materials, since most of the island of Mombasa was jungle, showing only a few isolated patches with cultivation or containing cocoanut trees. The crossing of Macupa Strait, which has a depth in parts of 14 ft. at high-water, with a tide that runs at times four knots an hour, was not an easy task, and a preliminary wooden bridge, one-third of a mile long and involving a diversion of two miles, had to be built, so that the work on the mainland, which could begin only after the strait had been crossed, would not be delayed until the iron bridge was completed. Almost immediately after reaching the mainland the formidable obstacle of the Rabai Hills had to be surmounted, which task entailed the heaviest work on the line in embankments and cuttings. In order to expedite the laying of the rails while this heavy work was being completed, considerable lengths of temporary lines, with gradients of 1 in 30 and curves of 400 ft. radius, had to be built. Similar temporary duplications of track had to be undertaken on various points along the remainder of the line, which naturally increased the work considerably. From Mazeras (mile 13½) onwards the line appears generally easy on section, but the ruling gradient and minimum curve had to be liberally used in order to avoid heavy work and expense, and frequent openings for cross drainage were required. While crossing the Taru Desert, which begins about 50 miles from the eastern terminus, and extends to about mile 132, the track resembles more nearly that of a surface line; but beyond Voi (mile 100) the features of the country admit of a ruling gradient of 1 in 66, although this had to be reduced temporarily by diversions to 1 in 30, while the permanent line was awaiting construction. Beyond Makindo (mile 207) the earth-work party had kept sufficiently ahead of the rails to dispense with the 1 in 30 gradients on diversions, and a ruling gradient of 1 in 50 sufficed, even on the temporary line. At mile 132 the Tsavo River had to be crossed; but, as in the case of Macupa Strait, a temporary diversion and bridge became necessary, pending the completion of the permanent structure. After completing the easy stretch between Tsavo to mile 162, the difficulties began again,

FIG. 4.—THE UGANDA RAILWAY: KIBWEZI STATION, MILE 188.

since from that point to Kibwezi (mile 188), owing to construction of several bridges, embankments, and rock-cuttings, many temporary diversions were required. Kibwezi (Fig. 4) is the head-quarters of the Scottish East Africa Mission.

The stretch of railway track to the west of Kibwezi shows but few signs of difficult work, excepting the construction of the bridges across the Kiboko, Kifaro, and Simba Rivers, until the neighbourhood of mile 258, when the line passes for many miles through broken country, involving hard work and temporary diversions, as far as the beginning of the Attu Plain (mile 280). From that point to the place where the railway crosses the Nyrobi (or Nairobi) River, the laying of the track offered no difficulty, except the crossing of the Stony Attu, the Attu, and the Ngongo rivers. The Nyrobi was reached on May 30th, 1899, and temporary headquarters were established, together with a basis of supplies, which involved the building of houses and huts for the staff, sheds for material and provisions, and sidings for rolling stock. With the resumption of work after crossing the Nyrobi (or Nairobi) the most difficult task began for the engineers of the Uganda road, as the character of the country beyond the Nyrobi River becomes extremely rugged and wild, and rushing torrents, descending from steep heights, compelled the workers to engage in bridge-work at very short intervals, or to lead the track aside along difficult and awkward curves. The natives, never over-anxious for hard work, became more and more unruly, and on one section they absolutely refused to continue on account of the appearance of a number of lions in the neighbourhood, who seemed to resent the intrusion of man into their mountain fastnesses, and carried off several of the workmen. As the white explorers and pioneers succeeded, however, in exterminating these monarchs of the wilderness, order was soon restored. Nevertheless, those among the natives who consented to work became less and less in number, while even those that accepted service gave but little satisfaction. When the news regarding this condition of affairs reached Europe, it was decided to employ Indian coolies for the work ; and as these can be engaged at merely nominal prices, most of them being ready to

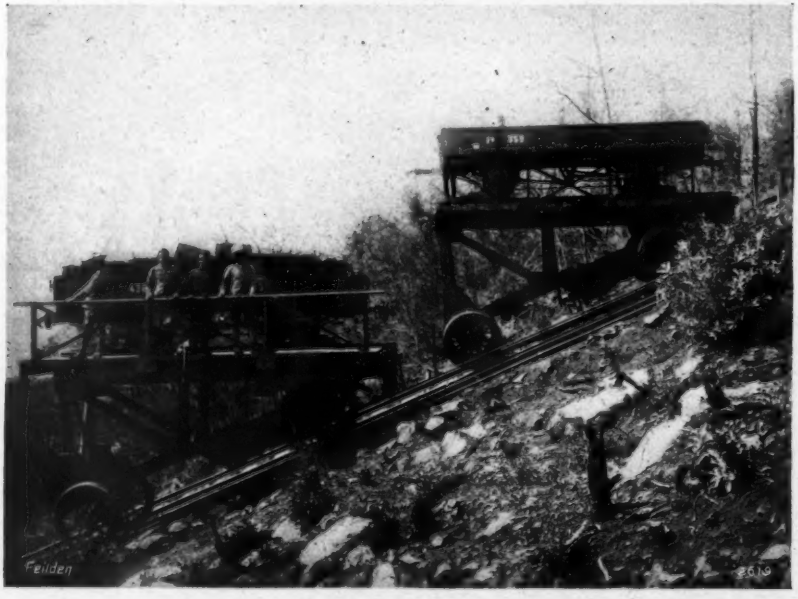


FIG. 5.—THE UGANDA RAILWAY: CARRIERS PASSING ON NO. 2 INCLINE. FULL GOING DOWN, EMPTY GOING UP. GRADE 1 IN 2.

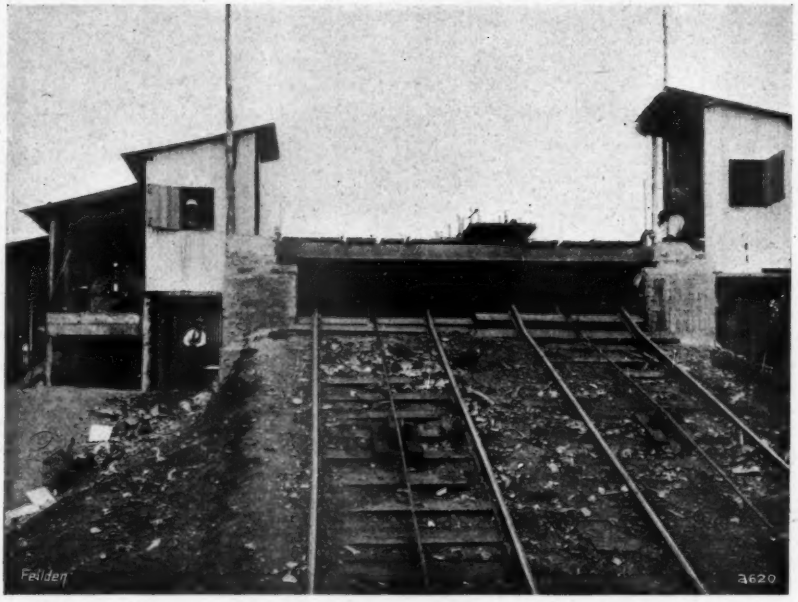


FIG. 6.—THE UGANDA RAILWAY: TOP OF NO. 2 INCLINE.

toil hard from 14 to 16 hours daily for little more than their bare sustenance, the importation of these men from India, quite accustomed to labour in a broiling sun and having nothing to fear from the climate, turned out to be a great success. At present the number of coolie labourers on the Uganda road amounts to nearly 20,000, while the few African natives still engaged by the company perform merely the simplest and most elementary work.

The country traversed after labour had been reorganised represents a sloping upland, well wooded, cultivated, and densely populated. It is much broken by spurs, however, running back from the backbone of the Kikuyu escarpment, alternating with ravines that increase in depth towards the north. No less than eight of these have to be bridged on this section by steel trustle viaducts, having a length from 120 to 780 feet, and in some places a height from 32 to 85 feet. Fig. 6 will give to the reader an idea of the gradient of the second incline of the Kikuyu escarpment, and shows two carriers, the loaded one descending while the empty one is ascending. Fig. 1 gives a view of the summit of the incline. Up to the Nyrobi the line follows the same general direction laid down by Major Macdonald, R.E., who started on a surveying expedition to this part of Africa in November, 1891, and returned in November, 1892; but from there a new route has been selected which has considerably reduced the difficulty of constructing the line across the much broken ground, and, after descending the very steep decline into the valley of the Rift River, immediately begins to climb up a slope equally precipitous until the summit is reached, near Mau Station, at a level of about 8,330 ft. and about 480 miles from the terminus on Mombasa Island. The advantages of the actually selected route over Macdonald's are that the ascent from the Nyrobi to the escarpment is much lighter than his, that the new route is about nine miles shorter, that it dispenses with two reversing stations and a 1 in 40 gradient, which is superseded by a gradient of 1 in 50, reduces the ascent of the Longonet saddle by nearly 500 ft. of rising gradient, and permitted the bottom of the rift to be reached at once by making use of a temporary rope incline, which greatly aided the expediting of the construction of the line in that section. In fact, the staking out of the

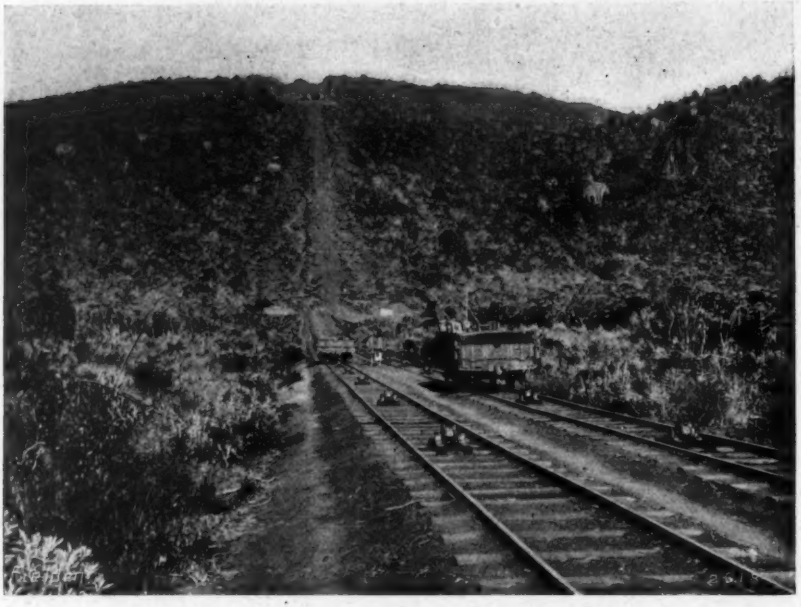


FIG. 7.—THE UGANDA RAILWAY: GENERAL VIEW FROM CENTRE OF NO. 4 INCLINE, NO. 1 NOT IN VIEW.

FIG. 8.—THE UGANDA RAILWAY: BETWEEN KIKUYU ESCARPMENT (ABOUT MILE 345) AND LIMOKO (355) ESCARPMENT, STATION 365.

line from Nyrobi to the lowest point of the descent is considered by experts to be, both in conception and execution, a masterpiece of engineering skill. Although the heights reached by the Uganda Railway are below those occurring in railway lines across the Rocky Mountains and the Andes, where 11,400 ft. and more above sea level are attained, the African line is the steepest by far of all the railways in the world, since it ascends to nearly 9,000 ft. in a course of about 500 miles.

Among the peculiarities of construction has been mentioned already the building of temporary bridges and diversions with curves of small radius. Even more interesting, however, are the devices resorted to to hinder the natives, when in want of iron, from annexing a few of the rails as the easiest way of supplying a long-felt want. To prevent this occurrence, which was considered probable by all who had experience in dealing with the aborigines, the engineers resorted to the simple remedy of bolting the steel rails firmly to the sleepers, and then of filing off the heads of the bolts, which renders the track so firm and solid that even skilled workmen, having numerous implements to aid them, find it a difficult task to lift the rails, while for natives it will be almost impossible to do so. Notwithstanding this, however, a railway police has been organised, visiting the line on light trollies, worked after the fashion of bicycles, at such short intervals that thieves or mischief-makers have but a poor chance.

Among other special features of construction may be mentioned the heavy concrete work rendered necessary on the Kikuyu escarpment and its very steep inclines. To the second of these allusion has been made already, and its character is easily seen in Figs. 5 and 6. The first incline of the escarpment is represented in Fig. 1, and Fig. 7 shows a fourth of these steep slopes, while Fig. 8 represents a curve on the escarpment about 10 miles west of mile 345. The chief difficulties of construction however, are not yet over after Mau summit has been reached. On the descent there are 70 miles which will require very laborious engineering work, including 28 steel viaducts, each 160 to 880 feet in length, from 30 to 110 feet in height, and it is stated that this will perhaps be the most expensive section of the whole line. The remaining few miles of the descent to the level of Lake Nyanza and the western terminus at Port Florence, are less burdened with serious problems. The terminus originally selected was Port Victoria, but it was abandoned both because the line to Port Florence is much shorter, and the serious obstacles to the engineering work are fewer. Even so, the descent to the Lake, though a far simpler matter than other portions of the line, is by no means a task unworthy of consideration, since 46 miles of the Lake terminus there will be a tunnel 200 yards in length, which is of special interest since it will be the only tunnel on the whole line. Still, there is a bare chance at least that the Uganda railroad will be finished by the end of the year, and, if so, its completion is not an unworthy achievement of the first year of the new century.

The Editor of "Feilden's Magazine"

Cordially invites his readers to send him early particulars of New Machinery, Improvements, Novelties, etc., for inclusion under this section. No charge whatever is made for the publicity afforded or for illustrations, nor is any *quid pro quo* expected. FEILDEN'S MAGAZINE undertakes the whole of the cost, merely stipulating that proper details, photos, and working drawings are supplied. If necessary, we will send our editorial representative to inspect and report on any special subject. The Editor, however, reserves to himself the right of accepting or rejecting any matter. In mutual interests we ask the earnest assistance of our manufacturers and others in order to bring constantly before the industrial world the best results of British engineering skill.

Practical suggestions for this section are invited, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice. Nothing will be too poor for a careful inspection.

❀ ❀ ❀

I.—ELECTRICAL ENGINEERING.

On the use of Carbon Brushes to cure Sparking at the Commutator.—In a station where I am electrician in charge, we have a dynamo somewhat similar to the one described in your Workshop Practice of August last. The brushes used at first, as the machine came from the manufacturers, were of copper foil, and there were three on each side of the commutator. Owing to an uneven turning movement in the engine, considerable trouble had been caused from flatting at certain parts of the commutator. On removing one of the brushes on each side of the commutator, and substituting for it a rather soft carbon brush, the trouble ceased. The engine was directly coupled to the dynamo. "DUNELMIAN."

[The points mentioned by our correspondent are of considerable importance, and we shall be glad to hear the experience of other charge engineers who have had similar difficulties. Few things give more trouble, either in a generator or motor station, than sparking at the brushes, and any simple plan of overcoming the trouble, notwithstanding the uneven running of the engine, will be a godsend. The plan adopted appears to meet the double difficulty of the conductivity of the collecting surface, and the quenching of the spark, which is usually an awkward problem.—ED.]

The Lubrication of Dynamos.—One of the most important factors in the continuous running of any machinery is efficient lubrication, and this is particularly the case with dynamo machines. The most efficient, in the writer's opinion, is the ring lubricator, but it is necessary to take great care in the design of the arrangements, and in particular of the section of the revolving ring itself. If the ring is of square section, as shown in Fig. 1, the top of the ring takes no part in the operation of lubrication, the lubrication being effected entirely by the underside, assisted to a small extent by the sides of the ring. The most efficient form of ring, in the writer's opinion, is that shown in Fig. 2, wedge-shaped or triangular in section. It allows the oil to drain off the sides, and has a large outer surface to carry the oil up from the oil well. Another good form, but more expensive, is that shown in section in Fig. 3. Its outer surface is perforated with holes, and in addition, an endless chain runs on the inside of the ring. The chain picks up a good quantity of oil from the oil well, and from the chain it passes through the holes in the ring to the machine shaft. Another important point is to know how much oil is in the oil well. A few makers supply a glass gauge to show the height of the oil in the well. The apparatus shown in Fig. 4 provides at the same time constant information as to the condition of the oil well, not only the height of the oil in the well, but also the condition of the oil, and also the usual drain cock for letting the oil run off. As will be seen, the gauge glass is mounted on the drain cock, the latter being made a little longer for the purpose. The oil, of course, assumes approximately the same height in the gauge glass as in the oil well, so that the attendant can see at a glance the whole conditions. "MECHANIC."

[This is also one of the important details upon which success or failure so often depend, and we shall be glad to have our readers' experience with different forms of lubricators. Many engineers even now swear by the old syphon lubricator, in its simplest form.

THE LUBRICATION OF DYNAMOS.

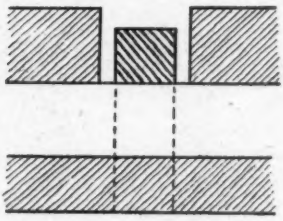


FIG. 1.

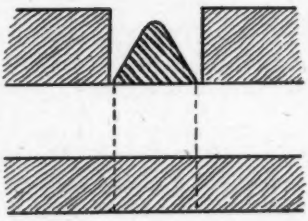


FIG. 2.

Others will have nothing but sight feed lubricators. The ring lubricator has been gaining ground now for some years, and there must be a very large number in use, of various patterns, some of them probably on the lines of the Figs. given above. Our readers' experience with different forms should be exceedingly interesting.—ED.]

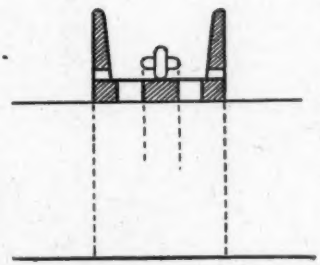


FIG. 3.

A Workman who knew too much and who made an Electric Motor Spark badly.—It was a compound-wound motor that was connected up for temporary service, and it sparked badly, and heated considerably. The shunt winding was found to be all right, also the armature coils. Careful inspection revealed the fact that the shunt and series field coils were connected up so as to oppose each other with regard to the magnetic circuit of the machine, so that the excitation was very much reduced. Reversing the connections of one of the coils put the matter right. It subsequently transpired that a workman had changed over the shunt wires when arranging for the machine to run in the reverse direction to that in which it had been previously running, and he had done this without any authority. He should have, of course, changed over the two brush leads.

H. M. M.

[Probably a good many of the troubles that vex the soul of the electrical engineer are due to the persistent non-ability of some workmen to understand that there is something in connections. Most of our readers will have been troubled in this way, and we hope they will give us the benefit of their experience.—ED.]

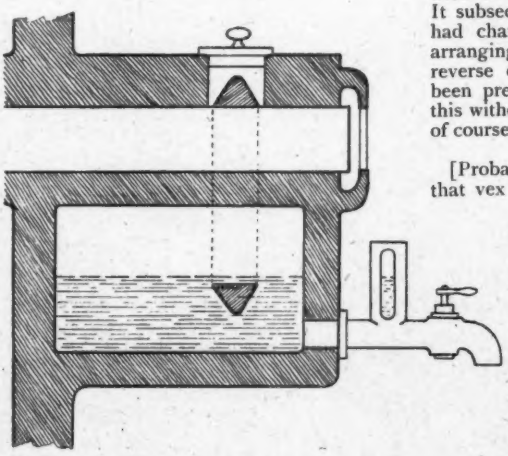


FIG. 4.

A Method of Constructing Drum-Wound Armatures for Small Dynamos.—A method which the writer has found satisfactory for preparing the armature cores of smal

dynamos for drum winding, is shown in the accompanying figures. A hollow cylinder of aluminium is provided, made in two portions, as shown in Figs. 5 and 6. Fig. 5 is a casting consisting of a hollow cylinder with a wide flange at one end, and Fig. 6 is a loose flange, similar in size, etc., and it is made to screw on the end of the hollow cylinder, so as to form, with the flange on the opposite end and the inner cylinder, a reel or barrel on which the armature core plates can be slipped. The end of the inner cylinder, which has no flange, has a male screw cut on its outer periphery, the flange ring that is to engage with it having a corresponding female screw. The casting shown in Fig. 5 is bored and slotted for the armature shaft. The radial depth, *B*, shown in Fig. 5 must equal the radial depth of the armature plates. The writer recommends that the thread on the end of the cylinder *A* should be 30 to the inch.

Having filled the space in the casting on the barrel *A* with the armature core plates, polished and shellaced only, screw up the loose flange plate tightly. Two holes drilled in each casting, diametrically opposite to each other, will facilitate this. The holes are shown in Figs. 6 and 7. It is advisable also to fit a set screw at the junction between the loose flange and the inner cylinder, to prevent any tendency to work back. Divide the peripheries of each flange into as many parts as there are sections of wire to be wound. At these points drill and tap $\frac{1}{12}$-in. or $\frac{1}{8}$-in. holes, and screw into each a short piece of hard brass wire. These will occupy only a very small space, but will hold the coils in place. Figs. 7 and 8 represent an end elevation, and a longitudinal section of a drum armature ready for winding. The writer claims for this method the following advantages :—

1. It allows the mass of iron to be kept as small as practicable, consistent with the magnetic flux required, so that losses due to hysteresis and eddy currents may be reduced to a minimum.
2. The deleterious effects of comparatively great weight and resistance of wire are avoided, as applied to a drum-wound armature.
3. No bolts pass through the core stampings.

(£1 1s. Award). D. W. GAWN.

[It would be interesting if our correspondent would send us some figures, giving the results of measurements upon some machines constructed upon the lines he suggests, and also some results as to their work in practice. Though there is a large prospective future market for larger and larger dynamos, there should also be a very large prospective market for small motors, suitable for use on small machines. There are two points that strike us, on which we should be glad if our correspondent would give us further information, and upon which we invite discussion from our readers. In our experience screws have not stood well in apparatus that is in motion, they tend to work back. The other point is, the net result, in efficiency, of our correspondent's arrangement of the armature plates and the containing castings, as against the plan usually adopted. Possibly other correspondents will give us the benefit of their experience in this branch of constructive dynamo work.—ED.]

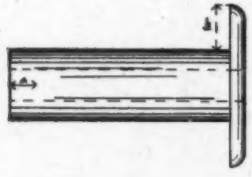


FIG. 5.

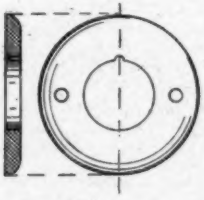


FIG. 6.

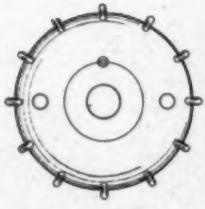


FIG. 7.

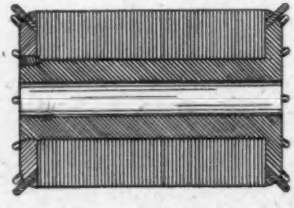


FIG. 8.

ARMATURES FOR SMALL DYNAMOS.

II.—MECHANICAL ENGINEERING.

A Boring Machine Attachment.—The facing appliance shown Figs. 1 and 2 is simple in design and capable of being utilised for a great variety of work, such as facing the flanges of cylinders, facings on large pedestals, or bosses of large diameter on machine tool castings. It may be used in connection with either a vertical or horizontal boring bar, and the square at the bottom provided with a cap, will permit of its being fixed on bars from 2½ ins. to 4 ins. diameter. The body *A* of the fixing may be a steel or hematite casting, which should be machined to a parallel width and also machined in the slot which encloses the neck of the toolholder *B*. This should be a sliding fit in the slot in which it is moved up or down by the screw *S*, the lateral strain being taken off the latter by the keep-plate *K* and nut at the back of the fixing. The tool is held in the block by a set screw as shown, and the feed is put on, by the star wheel *W* actuated by a small bracket or stop fixed on the boring table. In machining the fixing, great attention must be paid to ensure the sides of the square at the bottom, being at right angles to the face. In a large size fixing for heavy work, an extension of the bearing surface may be made as shown by dotted lines on the left of Fig. 1, whereby four or more bolts may be used in cramping to the bar.

J. GREEN.

Handy Charts for Workshop Reference.—In modern machine-tool building, uniformity of sizes and the finish of the several details have received much more attention than was formerly given in the older type of machinery, with the result that it has been found necessary in well-equipped and organised shops, to supply several charts, as Figs. 1, 2, 3, 4, 5, for the artisan's reference, and in order that no doubt shall exist as to the right sizes for keyways, heads of set-screws, the amount of projection and round on the ends of shafts, and, not least important, the sizes of nuts across flats and corners. The whole of the tabulated dimensions are standardised and issued from the drawing office for use in

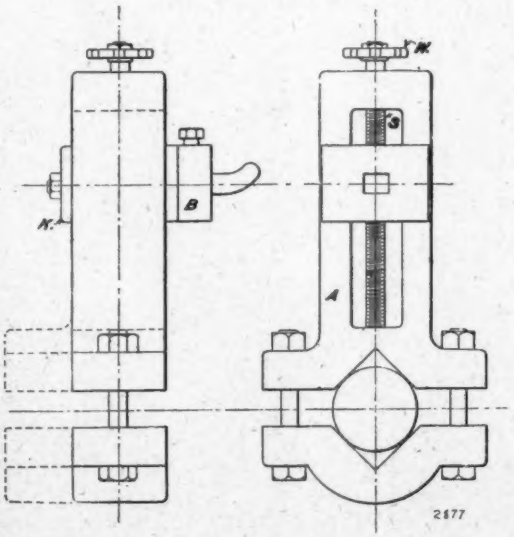
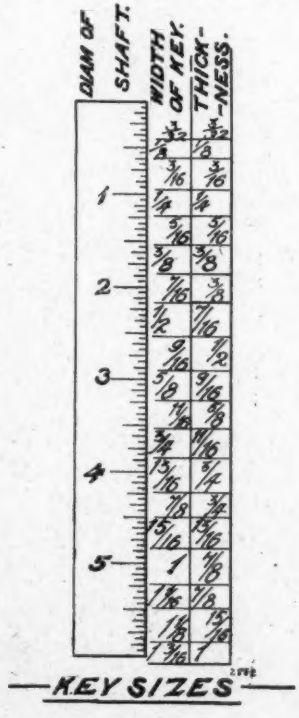
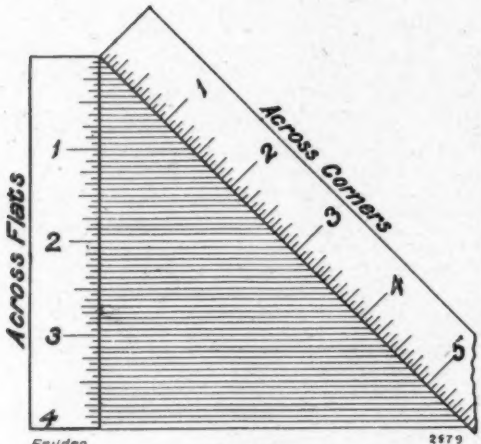


FIG. 1. FIG. 2.

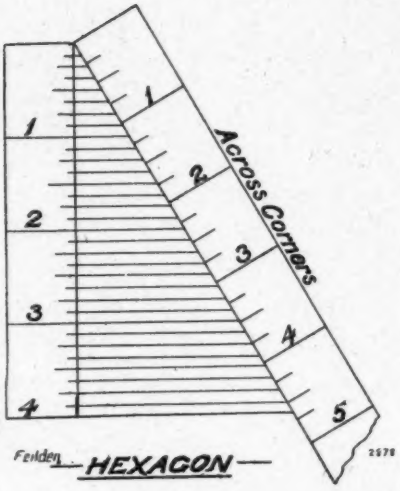
BORING MACHINE ATTACHMENT



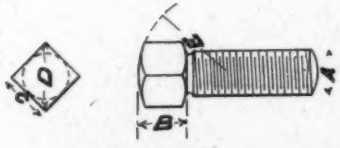
HANDY CHARTS.



—SQUARE—



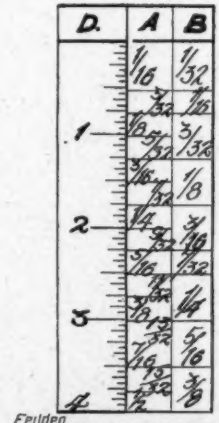
—HEXAGON—



A	B	C	D	E
1/4	1/4	1/4	11/32	1/2
5/16	5/16	5/16	7/16	5/8
3/8	3/8	3/8	17/32	3/4
7/16	7/16	7/16	5/8	7/8
1/2	1/2	1/2	23/32	1
9/16	9/16	9/16	26/32	1 1/8
5/8	5/8	5/8	7/8	1 1/4
3/4	3/4	3/4	1 1/16	1 1/2
7/8	7/8	7/8	1 7/32	1 3/4
1	1	1	1 13/32	2
1 1/8	1 1/8	1 1/8	1 9/16	2 1/4
1 1/4	1 1/4	1 1/4	1 3/4	2 1/2

Feilden 2580

—SET SCREWS—



—SHAFT ENDS.—

HANDY CHARTS FOR WORKSHOP REFERENCE.

the shops, in the form of blue prints mounted on boards and placed in some convenient but prominent position. This at once relieves the foreman or leading hand from a continuous volley of questions relative to the finish of the parts, and further secures—by adherence to sizes—a proportional uniformity. At no time has this been satisfactorily attained without method, as even skilful workmen vary when definite sizes are omitted. In workshop practice, we often find that one man's idea as to the rounding of a corner, or the distance beyond the bearing for a given diameter of shaft, differs from that of another man, and it is this which leads to disproportion and want of uniformity in the machine when finished. The tables are such as should be found in every works having pretensions to accuracy and finish, and will be most helpful in every department, being an accessory which is simple, cheap, and reliable.

A. F. HORTON.

Lathe Attachment for Milling Spiral Grooves in Caps, Rimers, etc.—The following is a description of a simple lathe attachment suitable for small shops where milling machines are not available. *A* is a plan, *B* a side and *C* an end elevation of the attachment for holding the work—which is held in the tool rest as shown, the length of which may be altered to suit different articles by means of the slide (*b*) and set-screws (*a*)—(*c*) is a centre, of which half is cut away to allow the milling cutter, which is placed in a chuck on the mandrel in the usual manner, to get well up to its work at the end ; (*d*) is a chuck carried on a spindle (*e*), and provided with four set-screws. This chuck is divided round its circumference, and a pointer (*f*) is provided, so that the chuck can be adjusted to give any required number of grooves. *D* is a view of an arm which is fixed on the end of spindle (*e*) by means of a set-screw when a spiral groove is required. The pillar (*g*) has one end which slides in the slot of the arm, while the other end slides in a frame, the details of which are shown at *E*. This frame is bolted to the slide-rest, and is tilted through an angle greater or less according to the twist required in the groove. As the work is fed at right angles to the cutter by means of the tool rest, the pillar (*g*) slides up the inclined frame and raises the arm to which it is attached, thus turning the spindle (*e*), and therefore the work, partly round. If a straight groove is required, the arm is removed and the spindle (*e*) adjusted by hand. J. E. L.

A plan of the completed arrangement is shown at Fig. 1.

Rack and Gear Cutting.—An adaptation of the shaping and slotting machines for rack and gear cutting as Fig. 1 and 2 illustrate the operations on each machine. In order to augment the output of two milling machines engaged in the work, the following devices were arranged. At the end of the shaping machine saddle, a strap of flat iron was fastened, having several $\frac{9}{16}$ in. holes of the same pitch as the rack. A hole drilled in the bed with a good fitting pin through the the bar held the same in position until the completion of each cut, two tools in the tool box—one roughing out and the other finishing—operating upon the stock at the same time. On releasing the pin and moving to the next hole, the rack teeth were very accurately spaced. The tools were filed and spaced to templet, the self-acting feed being put on until the full depth of the tooth was reached. Two racks were eventually cramped side by side, which gave an increase of output exceeding that of the milling machine. For the pinions the circular table of a small

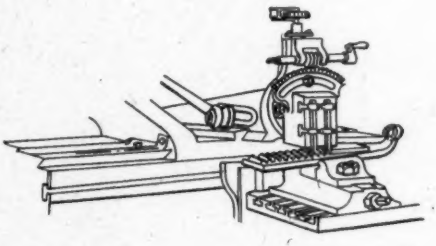


FIG. 1.

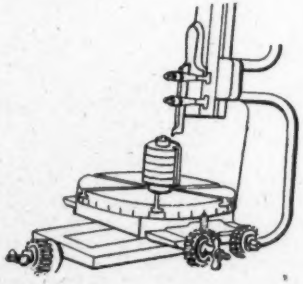


FIG. 2.

RACK AND GEAR CUTTING.

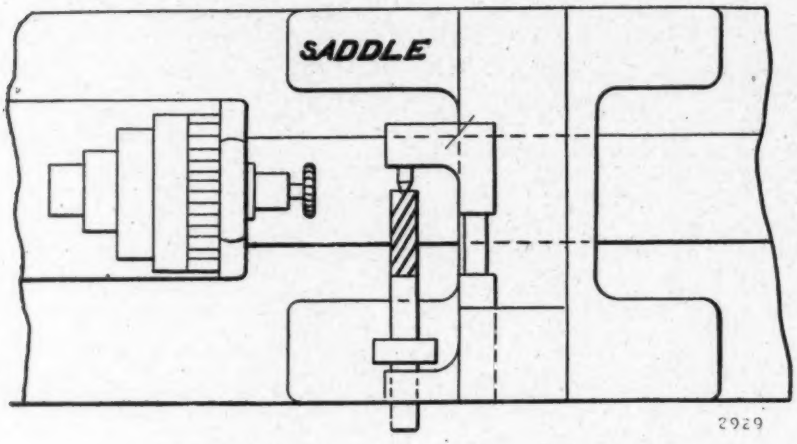
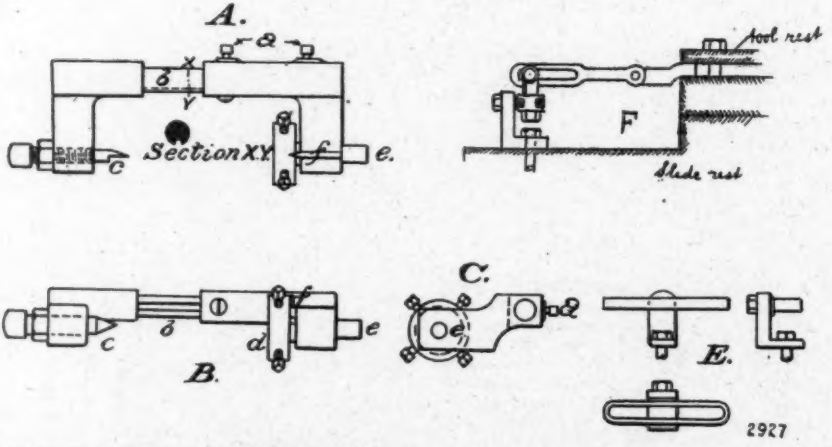


FIG. 1.



slotting machine was utilised, the edge of the table having division lines scribed upon it corresponding to the number of teeth in the wheels. Several of the blanks were threaded on a vertical spindle fixed in the centre of the table, a washer of the same diameter as the bottom of the tooth being placed between the table and the blanks for clearance of tool. A roughing-out square, cut round the periphery of the blanks at each division and a change of tool for the finishing cut, gave excellent results.

ARCH. SCOTT, JUNR.

LATHE ATTACHMENT FOR MILLING SPIRAL GROOVES.

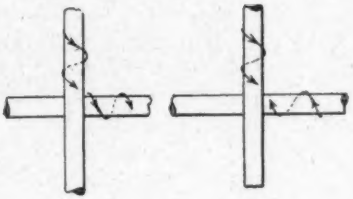


FIG. 1. FIG. 2.

QUARTER-TWIST BELTS.
REFERRED TO ON PAGE 395.

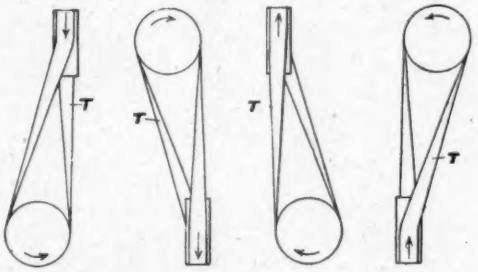


FIG. 3

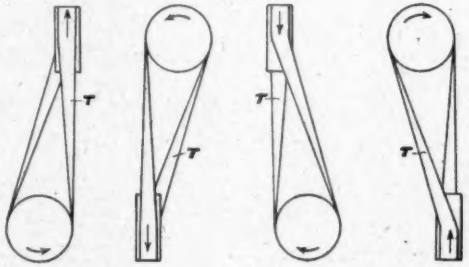


FIG. 4.

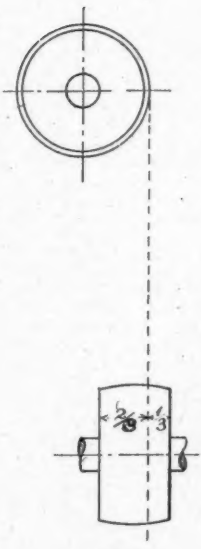


FIG. 5.

The purport of this section of FEILDEN'S MAGAZINE is to give the skilled mechanic an opportunity of bringing his practical ideas and experience into print. Inventive capacity and careful thought on the part of the workman is what we desire to encourage and foster. To this end we invite practical suggestions, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice, as, when draughtsmanship is at fault, we will do all that is necessary to render them fit for publication. Nothing will be too poor for a careful inspection.

ONE GUINEA WILL BE PAID FOR WHAT, IN THE OPINION OF THE EDITOR, IS THE BEST CONTRIBUTION OF THE MONTH.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

❀ ❀ ❀

Movable Accumulator Batteries.—Accumulator batteries, as we all know, are useful in two ways in electric lighting stations; first, they render it possible to add at any moment additional current to the maximum that can be furnished by the generators, and, secondly, they can take over the whole output when the machines are not running, either in consequence of an accident or of having been stopped for some special purpose, as, for instance, for economy's sake during periods of slack demand. Such batteries, however, have also, like everything else, their drawbacks, chief among them their high prime cost, which weighs most heavily where the demand is unequal and irregular, as, for instance, in watering-places and other summer resorts, where only for four or five months a heavy supply is required, and if batteries have been put into position to meet it, they would have to remain idle all the remainder of the year. It so happens, however, that the heavy demand in such places occurs only during the summer, *i.e.* during the season, when in the large cities the demand relaxes owing to the exodus of many persons to the country, and the slack season at the theatres and urban places of entertainment, a consequence to some extent of this exodus. This coincidence has suggested to our practical American cousins a simple method for reducing the loss due to the idleness of expensive apparatus for long periods of time. Their remedy consists in rendering portable the bulk of the accumulator plant, and in having the batteries so constructed that they can be securely fitted on the railway vans and despatched to any place where they are required. Thus during the summer, for instance, they supplement the generators in the central stations of seaside resorts, raising their output to any capacity required, while in winter they furnish current for the increased brilliancy in the great places of entertainment or at the numerous evening parties of the season. These portable batteries have, as can easily be understood, proved very successful, and we may safely predict that sooner or later the letting of batteries for longer or shorter periods will become a recognised and profitable business both in the United States and in Europe.

The Problem of Zinc Extraction.—Electric methods have of late so wonderfully simplified metallurgical prooesses that we have good reason for anticipating the solution by their means of most of the problems of obtaining metals from their ores in a fairly economical way. Many of these problems, however, have proved so far much more recalcitrant than we should have thought from their superficial aspect, and among these are some of considerable importance, the foremost perhaps being, as Mr. Swan pointed out in his very interesting presidential address to the Society of Chemical Industry at Glasgow, the economical extraction of zinc from its ores. Messrs. Brunner, Mond & Co. are at present, it is true, showing at the Glasgow Exhibition specimens of zinc of 99·6 per cent. purity obtained electrolytically, it seems, by a method resembling thr processes patented by the late Dr. Hoepfner, bu nothing definite is known as yet as to the cost and character of the *modus operandi* employed by these well-known chemical manufacturers. On the other hand we are face to face with the startling fact that under the very best circumstances it requires the consumption of from 1½ to 2 tons of coal for the production of 1½ to 2 tons of spelter from the richest ores. That this obvious waste of energy could be considerably reduced by substituting for the zinc-smelting furnace a well-equipped dynamo-plant and electrolytic furnace seems to go without saying, and yet there are a number of obstacles in the way of the electrolytic process that have to be removed ere the latter can bring about the much needed economy. Prominent among these is the fact that any silica contained in the ore is rendered gelatinous by the action of the acid, and in this condition holds a considerable quantity of the zinc in solution, so that filter presses are required to extract at least the bulk of the zinc. By roasting at a lower temperature ores that do not originally contain zinc silicate the formation of this gelatinous silica may be prevented, but in that case the zinc sulphide is only partially decomposed, and the action of the leaching medium is correspondingly limited. The discovery of a leach free from the drawbacks above mentioned is still waited for, but it will, of course, be made sooner or later, and there is little doubt that it will be well worth making.

The New Westinghouse Works at Manchester.—The British Westinghouse Electric Manufacturing Company, Ltd., have published a beautiful souvenir booklet, in commemoration of the laying of the foundation-stone of their new works at Trafford Park, Manchester, by the Lord Mayor of London, supported by the Lord Mayor of Manchester and Sheriffs of London, an event which promises to mark a new era in the electrical

engineering industry in this country, coming, as it does, with the flowing tide and at the very moment when from all parts of the United Kingdom reports are arriving showing that our manufacturers have been awakened from their long and drowsy lethargy, and that British people, desirous of availing themselves of the modern progress in electrical engineering, will no longer have to give their custom to foreigners, but will find at home all that they require equal to the best Trans-atlantic products as regards construction and design, and possessing, in addition, the advantages of high finish and solid workmanship common to all Britsh-made articles. Although the birth-place of the original Westinghouse Company was the United States, the ingenious machinery designed by its engineers has found a permanent place in many European countries besides our own, as for instance in Germany, Austria-Hungary, Russia.

The new works of the British Company which manufactures the Westinghouse types of electrical machinery and appliances, and which was formed in July, 1899, with a capital of £1,750,000, will occupy a portion of the Old Trafford Park Estate, an almost ideal situation for a great manufacturing establishment, being adjacent to both the Ship Canal and the Bridgewater Canal and in direct communication with the main line railways, while there are shipping facilities that place the works in direct connection with any part of the world. This will enable the Company to obtain raw material cheaply and expeditiously, and to dispose of their output under equally favourable conditions. Twenty-seven miles of railway track have been laid about the grounds for the trains conveying the 15,000 tons of steel and 10,000,000 cubic feet of timber for the construction of the works' buildings; and about 3,000 workmen will for some time be steadily employed in their erection, while, at the same time, the Trafford Park Dwellings Company, Ltd., is continuing the building of some 2,500 to 3,000 dwellings for workmen's residences, 300 of which have been finished, and an equal number is under construction. All of those projected, and many more probably, will soon be in demand; for after the opening of the works five thousand British workmen will be busily engaged in the manufacture of gas engines, dynamos, motors, converters, transformers, &c., of the Westinghouse type, and no doubt most of them will desire to have their home near the work, especially as the dwellings referred to will be up-to-date in comfort and sanitary arrangements, and will be supplied with both gas and electricity for lighting and heating at a moderate charge from the works directly.

Those who desire to obtain fuller information regarding what promises to be the largest electrical enterprise in the British Empire should not fail to peruse a copy of the "souvenir" booklet which, tastefully printed and excellently illustrated, contains on 115 oblong pages bound in an attractive cover, ornamented by artistic designs, a full description of the most important Westinghouse enterprises, being practically a kind of epitome of the present status of the application of electrical energy for industrial and municipal purposes.

Large Electric Railway Power Plant.—One of the largest single contracts ever awarded for electric railway power plant has just been given by the New York Underground Rapid Transit Company to the Westinghouse Electric and Manufacturing Company. This, the "first installation," will comprise six alternators of 5,000 kilo-watts each, three exciters of 250 kilo-watts each, twenty-six rotary converters of 1,500 kilo-watts each, and seventy-eight transformers each of 550 kilo-watts capacity. At the present time the work of building the tunnels is in progress. There will be in all some 21 miles of track and 48 stations. The line will be operated by direct-current, fed to the train motors from a third rail. It is worth noting that New York is evidently not prepared to embark on polyphase railway traction. As representing the opinion of the best experts of the day, the decision of the Company owning the latest electric railway venture of New York, should be of interest to those who are following the point of dispute between the two companies owning London's Underground.

The Recent Automobile Trials.—The recent 500 miles trials of the reliability of motor vehicles organised by the Automobile Club of Great Britain and Ireland, with the co-operation of the Scottish Automobile Club, and supervised by the Glasgow Exhibition Sports Committee, were most successful, and contribute valuable data to the history of the motor car in Britain. The primary object of the club was to demonstrate that the automobile has now passed out of its experimental stage. Reliability and endurance were to be the tests applied. Unless a car could stand the test of five consecutive days of hard work without developing mechanical defects, it stood no chance of being awarded a prize, whatever speed might have been developed. It is particularly gratifying to note the result achieved by the British cars, one in particular being signalised by gaining the maximum marks for the five days and the high aggregate of 270 for hill climbing, in class *A* of the manufacturers' section. A few details of this car, which is styled the Argyll Voiturette and is made by the Hozier Engineering Co., Ltd., may prove interesting. The car is fitted with a 6 b.h.p. high-speed motor, which is enclosed in aluminium casing and runs in oil. Immediately behind the motor and on the shaft is fixed a large-diameter friction clutch, which is actuated by a foot-pedal. Immediately behind this the gear-box is placed, which gives three forward speeds by means of sliding clutches, which are changed when the friction clutch is released. The gearing is so made that when the motor is running on the high speed, the driving-shaft runs straight through the gear-box, and none of the gear wheels are doing any work. In this way the noise from the gearing entirely disappears. The gearing is entirely enclosed in an aluminium box and runs in oil. The power is transmitted from the gear-box by means of a central propelling shaft, and actuates a live back-axle by means of bevel-gearing. The end thrust in this is coupled

by a ball-end thrust bearing. The whole of the differential gear and bevel-gearing in the back axle are enclosed in aluminium casing, which is filled with solidified oil. The whole combination therefore is enclosed in aluminium casings and runs in oil, so that all the gearing is therefore rendered dustproof, and the life is greatly prolonged. The car in practice can easily take four passengers on a fairly level road at 25 miles per hour. It will climb a gradient of 1 in 20, with four passengers, at the rate of 18 miles per hour; and, further, it will climb a gradient of 1 in 6, with four passengers, at the rate of 4½ miles per hour.

Motor Generators *versus* Rotary Converters.—An interesting test regarding the efficiency and suitability of two types of motor generators of considerable capacity was recently made under very favourable circumstances at the Oerlikon Works, Switzerland, of which a recent issue of the *Electrical World and Engineer*, of New York, contained an instructive account. The machines tested on that occasion were part of the equipment of two central stations for which the owners of the above-named works had received the order. Their type was that of the three-phase direct-current motor-generator, in one case consisting of a synchronous motor for 3,500 volts and 50 cycles, coupled to an eight-pole direct-current dynamo for a normal output of 260 volts and 1,350 ampères at 375 r.p.m.; in the other case, comprising a three-phase induction motor for 6,000 volts and 50 cycles, coupled to a four-pole direct-current dynamo for a normal output of 260 volts and 1,350 ampères at 370 r.p.m. Since there were several machines of each type available, it was possible to run the set under test under permanent full load without the expenditure of much energy. The arrangement made was such that one set was run with its three-phase current side as motor and its direct side as generator, while the other set was worked on the same circuits with its direct-current side as motor and its three-phase current side as generator. The measurements were in most cases made by the same interest, which was an additional precaution to insure accuracy. For comparison with the data of some machines by another manufacturer, consisting of a static transformer and a rotary converter with a common armature for three-phase and direct-current, values are taken from curves reproduced in the test. The sets furnishing these values consisted of three single-phase transformers and a rotary converter for a 550-volt direct current, the frequency being 25 cycles and the rated capacity 250 and 500 kilowatts respectively. For the details of arrangement and measurement the reader will have to refer to the American contemporary above named, in which the concise description is supplemented by instructive curves illustrating the successive result. Here it must suffice to state that, as regards the efficiency attainable, there appears to be not much choice between the three different systems. As far as the power factor is concerned the induction-motor system apparently remains from 5 to 10 per cent. behind the system employing a synchronous motor. On the other hand, where simplicity of the starting manipulation is an important desideratum, and where safety of service in the case of interruption to the line, and absence of the tendency of hunting of the generators are matters of moment, the tests have shown that the induction-motor system is by far the most excellent of all. Compared with the rotary converter, the motor-generator has the advantage that the tension of the direct current can be regulated without regard to the voltage of the alternating current, of which it is independent, and whose fluctuations do not interfere with it. To this must be added a feature of essential interest, from the designer's point of view, namely, the variable number of poles in both machines of the motor-generator system, which makes it possible to select as small a number as is required to secure perfect commutation of the current however great the frequency or the speed of the three-phase current motor may be, while in a rotary converter system a period exceeding 30 cycles per second necessitates so great a number of poles as to produce conditions very unfavourable for the commutation of the direct current.

Sheet-Metal Works at Shipley.—Extensions of buildings and plant at the works of Mr. W. P. Butterfield, manufacturer of galvanised tanks and cylinders, of Shipley, rendered necessary by the addition of a department for copper goods to the business, are now approaching completion. The additions include a large building, consisting of two floors, each measuring 150 ft. by 72 ft., and a dining-room, the latter having a separate entrance in order that it may be used by the workpeople in the evenings as a reading-room and club. Simultaneously with the opening of the new premises, Mr. Butterfield intends to put in force a lengthy set of rules, some of them being quite of a novel character, but all of which are specially designed to improve the discipline of the employés, and to create among them a personal interest in the welfare of the concern, and an *esprit de corps* which should contribute materially to the success of the business. The strictest punctuality is to be insisted upon, foremen will receive a bonus upon output, and there will be monetary rewards for suggestions calculated to cheapen and quicken production.

Personal.—We understand that Mr. James Paxman, the chairman of the well-known engineering firm, Davey, Paxman & Co., of Colchester, is on a tour through the United States, where he will visit the principal American engineering works. We have no doubt that this visit will have beneficial consequences both for his own Company and British engineering firms in general.

Conveyors.—Messrs. the New Conveyor Co., Ltd., Smethwick, have under construction a novel conveying plant, on the most modern lines, for a large banking firm, and will serve to convey the cash and books of the bank from and to the safe-rooms, a task usually consuming a considerable portion of the time of the employees that can be far more profitably employed in other ways.

In this section is presented every month a concise précis of the contents of the leading organs of the technical press and of the proceedings of the learned societies throughout Great Britain, the Continent, and America, and also, in a summarised form, the subject matter of the more important articles appearing therein.

With few exceptions copies of the articles referred to in this section can be supplied direct by us. Send post card for price and particulars.

ARCHITECTURE AND BUILDING.

1. Construction and Design.

Exhibition Buildings.—*The Horticultural, Forestry and Graphic Art Buildings of the Pan-American Exhibition.* Like most of the other exhibition buildings at Buffalo the Horticultural Building is built almost entirely of wood, and is elaborately decorated on the exterior with mouldings, relief work and sculpture. It is about 220 ft. square, 67 ft. high to the top of the first cornice, 106 ft. to the top of the second cornice, 150 ft. from the floor to the ceiling of the dome and 245 ft. from grade to the top of the finial above the lantern or the dome. The article contains a fairly full account of the structural details of this building and a short summary of the main features of the Forestry or Graphic Art Buildings.—*Engineering Record*, Aug. 24th, 1901, pp. 182-3. (Ill.)

Vault Light Slabs.—*Test of a Vault Light Slab.* Description of a loading test of a full-sized steel-concrete side-walk slab of the Ransome System, made at Union Square, New York, on August 27th, at the request of Mr. William Barclay Parsons, chief engineer of the New York Rapid Transit Railroad Commission, and under his personal direction. Cracks commenced to develop in the centre of the slab with a load of 5,484 pounds. When the load reached 10,054 pounds, they reached nearly to the corners, and somewhat before this several lenses cracked. Under the final load of 11,882 pounds, it had a relative vertical displacement of 1 inch.—*Engineering Record*, Sept. 7th, 1901, p. 230. (Ill.)

2. Heating and Ventilation.

Ventilating and Heating.—*Ventilating and Heating St. Mark's Church, Baltimore.* Description of the ventilating and heating plant in St. Mark's Lutheran Church, at St. Paul and Twentieth Streets, Baltimore, Md., U.S.A., which is warmed by hot air, distributed under a plenum system, which is assisted by aspiration near the exits of the vent passages, while the system of ventilation is an upward one, with air delivery through a large number of small openings in the ends of the various pews. The outflow of air takes place at the ceiling of the nave.—*Engineering Record*, Sept. 14th, 1901, pp. 255-6. (Ill.)

Ventilation and Heating in the Merchants' Loan and Trust Building, Chicago.—The article deals with the heating and ventilating plant in one of the latest office-buildings of Chicago; being 12 stories high above the side-walk and having a ground-plan of 78 by 177 ft. It is heated by steam, which is distributed throughout the offices by means of the downward system of piping—a type much in favour in Chicago, with gravity return, a vacuum system of circulation and an automatic temperature regulation; while it is ventilated in the banking rooms in the lower stories by a plenum and exhaust system of air distribution.—*Engineering Record*, Sept. 21st, 1901, pp. 279-80. (Ill.)

Heating and Ventilation.—*Ventilating and Heating Friendship School, Pittsburg.* Description of a very interesting and efficient heating and ventilating plant designed for a total air supply of 43,600 cubic feet of air per minute and for an exhaust of the same amount, based on a minimum supply of 30 cubic ft. of air per minute to each pupil. The supply to the rooms in the basement is based on a change of air five times per hour, and for the halls and corridors three times per hour, the architect in charge having been Mr. C. M. Bartberger, of Pittsburg.—*Engineering Record*, Sept. 7th, 1901, pp. 228-9. (Ill.).

3. Plumbing and Gasfitting.

Gas Fitting.—*Gas and Gas Fittings.* The present instalment on the subject deals with the subject of incandescent gas lighting. The author dwells on the fact that in all methods of artificially generating light the by far greater portion of the energy expended is changed into heat, and but a fraction of it appears in the form of light. In incandescent gas lighting the diffepence between the two forms of energy is not quite so great, and its introduction into public and private use marks a great step forward. The author passes in review the gradual development of this form of illumination, starting with Drummond's "limit jet," and describing the various kinds of mantles.—*Builder*, Sept. 21st, 1901, pp. 254-5; and Sept. 28th, pp. 275-6. (Ill.)

Plumbing.—*Plumbing in the Lying-in Hospital, New York.* Description of the interesting plumbing work done in the above-named hospital on Seventh Avenue, New York, between the Seventeenth and Eighteenth Streets, New York, in which a water supply of more than 150 gals. a minute under ordinary street pressure is taken through connections from separate mains in two streets. After passing through two 3-in. meters, valved both sides, it is received in a 3½-in. main, which is independently branched to the filters, the suction tanks, and the pumps. The aggregate capacity of the meters is sufficient to supply 200,000 gals. of water in 24 hours under average street pressure.—*Engineering Record*, Sept. 7th, 1901, pp. 230-32. (Ill.),

4. Miscellaneous.

Building Materials.—*The Quality of Stone Used for Concrete.* The author refers to certain experiments which have been carried out in the testing shops of the Royal Technical High School in Stockholm, showing that there is a great difference between the suitability of various stones for the manufacture of concrete. Concrete blocks were manufactured from five specimens of greenstone by identical processes. All of them showed the greatest variation both in weight and crushing strength,

the strongest being half as strong again as the weakest, although the weight per cubic yard did not differ by more than 4·4 per cent. This proves that the greatest care has to be taken in selecting the right kind of stone for concrete making.—*The Quarry*, Sept., 1891, pp. 553-54.

Lightning Protection.—*The Protection of Westminster Abbey from Lightning.* Description of a very complete plant of the air-to-earth type, designed by Mr. Killingworth Hedges, C.E., for the protection of Westminster Abbey from lightning.—*British Journal*, Sept. 25th, 1901, p. 105.

Stonehenge.—*The Preservation of Stonehenge.* The article deals with the work being done at present under the supervision of Sir Edmund Antrobus, who is carrying out the recommendations made by a committee, representing the Society of Antiquaries, the Wilts Archæological Society, and the Society for the Protection of Ancient Monuments, whom he had invited to advise him as to the best steps to be taken. Among other things, the tallest stone, the huge monolith which overhangs the altar stone, is being raised. and will be underpinned at its base with concrete, and excavations will also be made round one of the trilithons in the outer circle, on the Ambsbury side of Stonehenge, near the tallest stone, so as to support the base by concrete.—*Builders' Journal*, Sept. 25th, 1901, pp. 102-3.

Undermining of Buildings.—*The Effect of Railway Tunnelling on St. Paul's Cathedral, London.* Reproduction of the bulk of a letter by Mr. Somers Clarke to the London *Times* with short comments.—*Engineering Record*, Aug. 24th, 1901, p. 184.

CIVIL ENGINEERING.

1. Bridges and Viaducts.

Bridges.—*American Bridges.* Concise description of interesting features in a number of bridges and trestles manufactured in American shops for the Vera Cruz and Pacific Railroad. They were designed by Messrs. Waddell & Hedrick, of Kansas City for a single standard-gauge track and the live-loads specified for class W., in Mr. Waddell's "De Pontibus."—*Engineering Record*, Aug., 31st, 1901, pp. 196-7. (Ill.)

Bridge Reconstruction.—*The Safety of Brooklyn Bridge.* Under this heading are published editorial comments based on good common sense and worthy of serious attention. The writer deprecates alike an alarmist attitude and one of indifference. He advises a careful inquiry into the damage done to some portions of the bridge, and if possible a complete recomputation of the stresses, etc., under the present loads. It would be a matter of no surprise, he thinks, if such an examination thoroughly made should disclose the necessity of displacing some of the details of others better designed, nor would it probably be a very expensive operation, nor would this constitute a real criticism of the original design, it would be simply taking advantage of the material advances made in bridge design since the bridge was completed. Very reasonable, moreover, is his suggestion of a careful and systematic periodical inspection.—*Engineering Record*, Aug. 17th, 1901, p. 145.

East River Bridge.—*Erection of the New East River Bridge Approaches.* Description of the work being done in connection with these approaches which are 2,500 ft. and 1,744 ft. long, and weigh about 12,000 tons and 6,000 tons the Manhattan and Brooklyn sides of the river respectively. The standard structure consists of a three-deck steel viaduct 114 feet wide in the clear between hand rails, with 62½ feet foot-plate girder spans, and four longitudinal rows of vertical columns, spaced 11 feet and 43½ feet each side of the axis of the viaduct.—*Engineering Record*, Sept. 21st, 1901, pp. 266-8. (Ill.)

Highway Bridges.—*Highway Bridge Design and Construction.* The article is an editorial on the subject in which the author points out that notwithstanding the voluminous literature, no other class of structural work has on the whole experienced so little substantial improvement, if we except the large number of excellent iron and steel city street bridges in the United States. He hails, therefore, with great satisfaction the issue of "General Specifications for Steel Highway Bridges," by the American Bridge Company, which is supported in its authority by its own high standing and the fact that it is a member of the United Steel Corporation, of which powerful organisation it is a part. These specifications, some of which are printed as an appendix to the article, are clear and explicit, and occupy a standard which if adhered to will result in a decided improvement.—*Engineering Record*, Sept. 7th, 1901, pp. 217-18. (Ill.)

Modern Bridges.—*The Railway Bridge Across the Rhine at Worms.* Description of German railway bridge, finished last November at Worms, being a double-track bridge across the Rhine, about 3,054 feet long and differing considerably in many respects from the standard American practice. The river is crossed by a 383'2 feet channel span, and two 355'3 feet side spans, and at one end there is an approach with seventeen dark-truss spans of about 115½ feet. The abutment piers at the end of the side spans are very massive, with heavy masonry arches, and superstructures rising considerably above the tops of the trusses so as to form impressive portals which afford an opportunity for architectural embellishment.—*Engineering Record*, Sept. 14th, 1901, pp. 245-46.

Viaducts.—*The Boona Viaduct.* The general features of this viaduct were given in an article published in the paper below named, on July 13th, and referred to in this place in the September issue of *Feilden's Magazine.* The present article describes some details of the steel work and its direction.—*Engineering Record*, Aug. 24th, 1901, pp. 171-73. (Ill.)

2. Canals, Rivers and Harbours.

Canal Building.—*The Canals of Canada.* Under this heading is presented to the reader a very lucid and instructive account of the topographical conditions in the region of the great lakes of North America and the gradual development of a canal system, which is beginning to assume gigantic proportions, unrivalled anywhere, and is of the utmost importance for the trade and commerce of the Dominion.—*Builder*, Sept. 29th, 1901, pp. 263-6. (Ill.)

Dams.—*Stability of Small Dams.* By John H. Gregory, Assoc.M.Am.Soc.C.E., Assistant Engineer, Improvement of Water Supply, Philadelphia. The author discovered that though there is an abundance of literature on methods for determining the proper dimensions for small masonry dams, few of the formulas were in such a shape as to be readily applicable. Having to execute a sign involving the determination of a number of sections under various assumptions as to top width and batter on the back and on the down-stream face, a series of formulas was deduced by him which would give by the solution of one equation the width of the base, that being the dimension required. These useful formulas he presents in the above-named contribution to his readers.—*Engineering Record*, Sept. 21st, 1901.

Harbour Works.—*Bilbao River and Harbour.* By Señor Don Evaristo De Churruca, chief engineer of the Bilbao River and Harbour Works. This is a paper read before the International Engineering Congress at Glasgow, in which the author, after giving a short account of the work done by the Bilbao Harbour Board to improve the river and the bar, describes the harbour of refuge in course of construction in the Bay of Bilbao; an interesting feature being the use of large steel caissons in building the main breakwater, rendered necessary owing to the difficulties caused by the violent action of the sea during north-westerly storms.—*Engineering*, Sept. 27th, 1901, pp. 460-63. (Ill.)

Ship Canals.—*The Projected Würtemberg Ship Canal.* Concise summary of the project of building a canal from Mannheim to Esslingen, about 200 kilometres in length, at an estimated cost of £2,500,000, which would secure to the kingdom of Würtemberg—which is the only one of the South German states which has as yet no direct connection with the sea, a navigable waterway furnishing such connection.—*Engineer*, Sept. 27th, 1901, p. 335.

Zuider Zee.—*The Zuider Zee.* Concise summary of the latest scheme for reclaiming the Zuider Zee, based on the report of a Commission, consisting of 27 members, appointed in 1892. In this scheme the idea of reclaiming the whole area now covered by water, by uniting the five islands on the coast by

embankments, was abandoned for commercial reasons, and the present intention is to enclose the inner portion of the sea, *i.e.* an area of 560 square miles, by an embankment 18 miles in length, and by four enclosure banks; into this inland sea the river Yessel and other waterways would discharge. The first cost of the scheme is estimated at £7,916,667, of which £2,344,167 is for the great enclosing dyke from Wieringen to Piaam. The advantages to be derived from the realisation of this project are described in the summary, together with the ways and means of raising the expenditure.—*Engineer*, Sept. 27th, p. 1322. (Ill.)

ELECTRICAL ENGINEERING.

1. Theory.

Conductivity of Metallic Particles.—*On the Change of Conductivity of Metallic Particles under Cyclic Electromotive Variation.* By Prof. Jagadis Chunder Bose, M.A., D.Sc. This is a paper read before Section A of the British Association. A mass of conducting particles has its conductivity changed when subjected to rapid electric vibration, as, for instance, when acted on by electric waves. The author describes the results of an investigation consisting of the determination of the variation of conductivity of the sensitive particles as the mass is subjected (1) to a continuously increasing E.M.F. from zero to a maximum, and then (2) to a continuously diminishing E.M.F. from the maximum back to zero, and the various means by which the required information was obtained, together with the experimental modifications required to overcome numerous difficulties in the practical solution.—*Electrician*, pp. 830-32. (To be continued.)

2. Electro-Chemistry and Metallurgy.

Dielectric Constants.—*Determination of the Dielectric Constants of some Bodies belonging to the Pyridine and Piperidine Series, by Drude's Method.* By R. Ladenburg. The author, happening to be in possession of a number of homologous bodies belonging to the group of pyridines and piperidines, experimented with them with reference to their dielectric constants, in the hope of discovering some connection between this and the constitution of these bodies, a hope, as his contribution shows, partly fulfilled.—*Zeitschrift für Electrochemie*, Aug. 8th, 1901, pp. 815-17.

3. Measuring Instruments and Methods.

Measuring Instruments.—*Kelvin's Electric Measuring Instruments.* By Professor Magnus Maclean, D.Sc., M.I.E.E., Abstract of a paper read before Section IX of the International Engineering Congress, in which the author gives an interesting account of the ingenious inventions of Lord Kelvin in the field of electric measurements, the extent of which will be realised when it is stated that the great scientist has within the last twenty years—*i.e.* since exact electric measurements were introduced into electric practice – taken out twenty-seven patents relating to improvements in instruments for generating, regulating, measuring, recording, and integrating electric currents, to which must be added eleven other patents referring to improvements in electric telegraphic apparatus.—*Electrical Review*, Sept. 6th, 1901, pp. 385-8. (Ill.)

4. Dynamos, Motors, and Accessories.

Electric Generators.—*Large Generators.* The article deals with generators built by the English Electric Manufacturing Company at Preston. This company, though work in its establishment began but in June of last year, has built since then about 1,500 tramway motors, varying in size from 25 h.p. up to 100 h.p., supplying at the same time the necessary controllers, rheostats, and car equipments for 750 cars. A far more important kind of work, however, has begun recently at Preston—namely, the production of direct-current generators, both for lighting and power, varying in capacity from 100 to 1,200 kw.; and it is with them that the contribution above named is specially concerned.—*Electrical Review*, Sept. 20th, 1900, pp. 474-7. (Ill.)

5. Electric Transmission of Power.

Electrical Manufacturing Works.—*The New Westinghouse Works at Manchester.* Description of the above-named works, located mainly in six buildings each of which is devoted to some special kind of manufacture, and equipped in the most perfect manner for the work to be done in it. Besides these six buildings, in which the actual work is carried on, there are two others, one of these containing the office premises, in which a large clerical staff will be employed, while the second will give shelter to the box factory, and contain the stores.—*Electricity*, Sept. 6th, 1901, p. 485.

Electric Plant.—*A British Polyphase Installation.* The above title refers to the factory of Messrs. Fletcher, Russell & Co., Ltd., makers of gas stoves and articles of domestic economy, as well as heavier types of workshop appliances. This factory was removed from Pendleton to Warrington about three years ago, and is equipped in the most efficient manner, including an interesting three-phase electric plant.—*Electrical Review*, Sept. 6th, pp. 379-81. (Ill.)

Electricity Supply Works.—*The Kensington and Notting Hill Companies' Joint Electricity Supply Works.* Under this heading is described a Metropolitan supply system of considerable interest, and noteworthy among others for the facts that, for the first time, two companies within the Metropolitan area have combined to build a joint station, and that, for the first time also in this country, a system of any magnitude has been adopted which has employed asynchronous motor-generators in its sub-station equipment.—*Electrician*, Sept. 6th, 1901, pp. 738-43; Sept. 13th, pp. 779-81 and Sept. 20th, pp. 818-20. (Ill.)

Electricity Supply Systems.—*Farnworth Municipal Electric Tramways and Lighting.* Description of the system now being operated by the Urban District Council of Farnworth, a town of about 30,000 inhabitants. This combined electric lighting and traction plant was adopted on the advice of Messrs. Lacey, Clirchugh & Sillar, consulting engineers, and a sum of £22,000 was granted as a loan after a Local Government inquiry, to defray the expenditure.—*Electrician*, Sept. 6th, pp. 749, 750. (Ill.)

6. Electric Lighting.

Candle Power Measuring.—*A New Lumen-Meter.* Description of a new form of "lumen-meter" placed upon the market by Messrs. Queen & Co., of Philadelphia, designed for the rapid measurement of the mean spherical candle-power of incandescent lamps. The apparatus is manufactured under the patents of Messrs. Houston & Kennelly, and is a modified design of the arc-light lumen-meter.—*Electrical World and Engineer*, Sept. 7th, 1901, p. 395.

Electric Mining Lamps.—*Electric Lamps in Mines.* Digest of a paper by Mr. W. O. Wood, read before the North of England Institute of Mining and Mechanical Engineers in Newcastle-on-Tyne, in which the author describes the electric lamps, dynamos, etc., in use at the Murton Collieries, pointing out that although the miners were at first prejudiced against the innovation, they were at present quite reconciled to it. The number of failures in the ordinary oil lamps amount to about 2·11 per cent. of the number of lamps in use; those of the electric lamps were but slightly more in the beginning, namely, 3 per cent.; at present, however, they are only 0·01 per cent., in fact it is, according to the author, a most unusual thing for a lamp to go out, except when crushed or broken by actual violence.—*Electricity*, Sept. 20th, 1901, pp. 523, 524.

Luminous Fountains.—*A Brief History of Luminous Fountain Development.* By Luther Stieringer, A.I.E.E. The author gives a concise but interesting review of luminous fountains in which the light is furnished by electricity, first among which, according to him, was an illuminated fountain designed by Sir Francis Bolton, of England, which was shown at the Health Exhibition, in London, in the year 1887, and the finest display of this kind seems to be that seen at Buffalo at present in honour of the Pan-American Exhibition.—*Electrical World and Engineer*, Sept. 17th, 1901, pp. 417-23. (Ill.)

7. Telegraphy and Telephony.

Telephone Exchanges.—*Glasgow Municipal Telephones.* Description of the telephone exchange above-named, for which the city obtained a licence under the

Telegraphs Act, 1899, enabling it to work telephones over an area of about 1,430 square miles, embracing a considerable area of the environs of the city of Glasgow, including portions of Lanark, Renfrew, Dumbarton, and Stirling. Work was begun in July, 1900, and was carried on so energetically that the operating service was inaugurated in the month of March of the present year, and supplies at present 1,450 subscribers, while 4,000 more await connection.—*Electricity*, Sept. 13th, 1901, pp. 499, 500.

8. Materials and Methods for Conducting Currents.

9. Electric Traction.

Electric Train Control.—*The Thomson-Houston System of Train Control.* The Central London Railway Company is experimenting at present with a train equipped with the new system of train-control which is being introduced by the Thomson-Houston Company, and under the above heading is given a detailed description of the equipment of a train of the French Western Railway extension line running into Paris, consisting of the multiple control system of the Thomson-Houston Company, which in all essential features is similar to that being experimented with in London. — *Electrician*, Sept. 6th, 1901, pp. 743-6. (Ill.)

Electric Traction in Brazil.—*The System of the São Paolo Tramway, Light & Power Company, Ltd.* Description of electrical enterprise in São Paolo, a thriving Brazilian town, capital of the state of the same name which contains 5,000,000 inhabitants, where a traction and lighting plant, undertaken by English and American capitalists some three years since, was opened to traffic this year, the water-power, with a capacity of 20,000 h.p., being obtained at a distance of 20 miles from the town.—*Street Railway Journal*, Sept., 1901, pp. 167-74. (Ill.)

Electric Tramways.—*Birkenhead Corporation Electric Tramways.* Description of the three roads, opened on August 14th this year, which bring the present route-length up to 7½ miles, and the balance of the system, which will comprise 12½ miles, will be completed as soon as possible.—*The Tramway and Railway World*, Sept., pp. 457-67. (Ill.)

Electric Tramways. — *The Southport Tramways Company's Electric Lines.* Description of the above electric tramway system, which has a total length of 5 miles 280 yds., of which 3 miles 1,334 yds. are double track, and the remaining 1 mile 706 yds. single track, giving a total track length of 8 miles 1,614 yds.—*The Tramway and Railway World*, Sept. 12th, 1901, pp. 471-75. (Ill.)

Tramway Working.—*Recent Tramway Practice.* By James More, Jun., M.I.C.E., F.R.S.E. The author gives in this paper, read at the International Engineering Congress at Glasgow, a concise review of present practice, and the accessible data, with a few remarks on the different methods.—*Electrical Engineer*, Sept. 20th, 1901, pp. 405-11. (To be continued.)

High Potential Systems.—*The Control of High Potential Systems.* By E. Rice, Junr. The author points out that the great advances in the capacity and voltage of generators would be useless, if not positively dangerous, unless adequate means for controlling and switching the electrical current were at hand; that for a time the evolution of the dynamo was more rapid than that of such devices, and the problem how to produce a switch which would retain all the advantages of the usual oil switch, and at the same time minimise the quantity of oil, remained unanswered until it received a remarkably satisfactory solution in the type evolved and employed in the installation of the Metropolitan Traction Company of New York, with which company the author is connected. This type, known as the Form "H" oil-switch, was in fact designed by Mr. Rice, Junr., with the assistance of Mr. E. M. Herslett, and the principal features are given in the present article, together with many instructive data connected with the question of control.—*Electrical World and Engineer*, Sept. 7, 1901, pp. 374-8. (Ill.)

Novel Cars.—*A Large Combination Car.* Description of combination luggage and passenger coach, recently finished for the Buffalo and Lockport Railway, and having some rather unusual features. The type is becoming popular with American electric railway companies, and was placed upon the market by the J. G. Brill Company, which endeavoured to combine the best features of steam as well as of electric railway cars.—*The Tramway and Railway World*, September 12, 1901, p. 481. (Ill.)

Polyphase Railways.—*The Zossen Polyphase Railway Installation for Experimental Trials with Speeds up to 125 miles an hour.* By Walter Reichel. The author, chief engineer of the famous electrical manufacturing company of Siemens & Halske, of Berlin, describes under the above heading what is perhaps the most interesting experimental installation in existence, and the results obtained there will be watched with considerable interest by electricians all over the world.—*Electrical World and Engineer*, Sept. 7, 1901, pp. 367-72. (Ill.)

Railway Generators.—*The Largest Direct-current Electric Generators.* Description of two Westinghouse steam-driven generators, by which the power plant of the Boston (Massachusetts) Elevated Railway is about to be enlarged. The two sets are exactly similar, both having a normal full-load capacity of 4,000 h.p. The engine is about 38 ft. high, 40 ft. long, and 28 ft. wide; the normal speed is 75 revolutions per minute. The generators are the largest ever built for traction purposes. Their normal capacity is 2,700 kw. each at a pressure of 600 volts.—*Tramway and Railway World*, September, 1901, pp. 468-70. (Ill.)

Railways. — *The Niagara, St. Catherines, and Toronto Railway.* By E. F. Seiras. The author gives an interesting description of one of the first short electric railroads that have superseded a steam railway line—namely, the line which embraces the works of the old Niagara Central Road, formerly connecting Niagara Falls, Ont., and St. Catherines, Ont., with an extension of six miles from St. Catherines to Port Dalhousie, on Lake Ontario, and a boat service from the latter place to Toronto.—*Street Railway Journal*, September, 1901, pp. 180-82. (Ill.)

Towing System. — *The Miami and Erie Canal Towing System.* This is an editorial on the fact that Mr. Thomas Fordyce, under whose charge the Miami and Erie Canal Railway is being built, has obtained a lease from the State of Ohio to build a line on the tow-path for haulage by electricity of canal boats. Although this lease does not contemplate the curtailing of the rights of towage by the old mule method, it is expected that when the railway is completed, most every one will use the trolley lines.—*Electricity* (New York), Sept. 11th, 1901, p. 146.

Train Signalling.—*Train Movement Signalling on the Boston Elevated Railway.* By Howard S. Knowlton. Discussion of one of the many interesting problems that came into existence with the building of the Boston Elevated Railway, of which the main line was opened to traffic during the month of June this year. The problem here dealt with is that of an efficient signal system, which, in the tortuous streets of Boston, is of paramount importance. The solution found and described in this article is the adoption of a block system, in which the signalling is performed by pneumatic pressure.—*Street Railway Journal*, Sept., 1901, pp. 155-9. (Ill.)

MARINE AND NAVAL ENGINEERING.

1. War Vessels.

An Ancient Frigate.—*The United States Frigate "Hartford."* The vessel bearing the above name is one of the few specimens of the old wooden navies still extant, and by reconstruction has obtained a new lease of life. She earned fame during the American Civil War, and especially as Admiral Farragut's flagship at Mobile Bay. The *Hartford* was built at the Boston Navy Yard, and was launched in 1859. The length is 225 ft., beam 44 ft., displacement 2,550 tons.—*Marine Engineering*, Sept., 1901, p. 372. (Ill.)

Auxiliary Vessels.—*Mercantile Auxiliaries.* This is a paper on the subject above-named by the Right Hon. Lord Brassey, K.C.B., D.C.L., read at the meeting of the Institution of Naval Architects, in which the author

strongly urges that while the building of cruisers for the Navy should, of course, be continued, the resources we possess in the marine, in extent practically without limit, should not be neglected.—*Marine Engineering*, Sept., 1901, pp. 369-72.

Gunboats.—"*Teal*" *and* "*Moorhen.*" Description of two shallow-draft gunboats built by Messrs. Yarrow & Co., Poplar, for the British Admiralty, their dimensions being—length 160 ft., beam 24 ft. 6 ins.—*Marine Engineer*, Sept. 1, 1901, p. 221. (Ill.)

2. Freight and Passenger Vessels.

Turbine Steamers.—*The New Turbine Steamer* "*King Edward.*" Description of a new turbine steamer built by Messrs. William Denny & Bros., the engines being supplied by the Parsons Marine Steam Turbine Company, Ltd., Wallsend-on-Tyne, and the boilers were constructed by Messrs. Denny & Co., Dumbarton. The *King Edward* is 250 ft. in length, the beam being 30 ft. and the moulded depth to the main deck 10 ft. 6 ins.—*Steamship*, Sept., 1901, pp. 99, 100. (Ill.)

3. Pleasure Boats.

Yachts.—*Twin-Screw Pleasure Yacht* "*Prinzessin Luisa.*" Description of a novel kind of vessel built for the Hamburg-American Line by Messrs. Blehm & Voss, of Hamburg, intended solely for pleasure cruises and long excursions, being in outward appearance and general equipment a large yacht, having an extreme length of 446 ft. and extreme breadth of 47 ft., a depth of 29·76, and a dead-weight capacity of 2,032 tons. First-class accommodation only is provided, and 200 passengers can be carried in 123 cabins.—*Marine Engineering*, Sept., 1901, pp. 363-8. (Ill.)

4. Miscellaneous.

Launching.—*Launch of the Mallory Steamer* "*Denver.*" The launch to which this contribution is devoted presented features of more than usual interest owing to the large dimensions and great weight of the vessel and the narrow stream into which she was launched. The *Denver*, built for the Mallory Steamship Company of New York, at the works of the Harlan & Hollingsworth Company, Wilmington, Del., U.S.A., has a length over all of 386 ft., a beam moulded of 48 ft., and a depth to awning deck moulded of 35 ft., having a dead-weight carrying capacity on 19 ft. of 3,000 tons. Before launching she rested in the ways at an inclination of an inch to a foot, and as the width of the Christiana River at this point is hardly one and a half times the length of the *Denver*, the question of bringing the boat to a standstill in a little over her length required considerable attention. The method of "snubbing" was employed, and this, together with the way in which many other obstacles were overcome, forms the interesting subject-matter of the article.—*Marine Engineering*, Sept., 1901, pp. 378-84. (Ill.)

Righting of a Vessel.—*The Turning of the Dredger* "*Canton River.*" Under the above title is given an interesting and fairly full account of the successful operation performed by Captain Percy Scott, of H.M.S. *Terrible*, in righting a dredger at Hong Kong, which, in November, 1900, during a typhoon, had foundered 380 ft. from the sea-wall. On December 17th, 1900, H.M.S. *Terrible* arrived, and finding the dredger still bottom upward, an offer was made to right her, but not to raise her as well. The offer was accepted, the work was begun on January 2nd, 1901, and on January 12th the dredger was righted. This and the subsequent operations, some of them being very difficult, until the dredger was floated, showed great ingenuity and resourcefulness on the part of the Naval officer above named.—*Marine Engineer*, Sept. 1st, 1901, pp. 213-15. (Ill.)

MECHANICAL ENGINEERING.

1. Boilers, Furnaces and Fuel.

Boiler Testing.—*A Few Points on Boiler Testing.* By John W. Fletcher. The author describes the most suitable methods of testing land or marine boilers, whether new or old.—*Scientific American*, Aug. 31st, 1901, pp. 136-7. (Ill.)

2. Compressed Air.

Compressed Air.—*The Contractor's Power Plants on the New York Rapid Transit Railway.* Under the above heading are described the situation and equipment of eight stations, most of them built under difficulties on account of lack of space, for supplying the compressed air required for hoisting engines, drills, and all kinds of machinery.—*Engineering Record*, Aug. 3rd, 1901, pp. 102-6. (Ill.)

3. Engines and Motors.

Agricultural Machinery.—*Canadian Agricultural Machinery.* By Mr. G. Harwood Frost, B.A.Sc., Smith Falls, Ontario, Canada. Under the above title is reproduced a paper read by the author before the International Engineering Congress at Glasgow.—*Engineering*, Sept. 27th, 1901, pp. 445-7. (Ill.) (To be continued.)

Blowing Engines.—*Compound Blowing Engine at the Askam Iron Works.* Description of an engine built with the object of bringing British blast-furnace practice more in harmony with American practice. Until recently the air pressure used in this country in blast furnaces ranged from 4 lbs. to 6 lbs. per square inch; but it has lately become apparent that pressures up to, say 20 lbs. per square inch, may be required, for which provision is made in the United States; and the engine here described, which was built by Messrs. Galloways, Ltd., of Manchester, for the Askam Iron Works, was constructed to supply this requirement.—*Engineering*, Sept. 13th, 1901, p. 365. (Ill.)

Condensing Engines.—*Steam Heat with Condensing Engines.* By Alton D. Adams. The author deals with the vacuum system for heating with steam from condensing engines, and the advantages to be obtained from the use of exhaust steam.—*Scientific American*, Aug. 24th, pp. 118-19.

Cranes.—*Novel Cranes.* By Waldon Fawcett. The author gives a concise account of a number of alterations in construction, being improvements, in the existing types of cranes.—*American Manufacturer*, Aug. 15th, 1901, pp. 993-4.

Fire Engines.—*Self-Propelled Fire Engines.* By Waldon Tawcett. The author describes the self-propelled fire engines used by the Municipality of Boston.—*Scientific American*, Aug. 17th, 1901, p. 105. (Ill.)

Oil Engines.—*The Rocket Oil Engines.* Abstract of a contribution to the *Journal* of the British Society of Mining Students, by Mr. Sydney Bates, containing some interesting particulars regarding a 12-b.b.p. Rocket oil engine, used for hauling coals from a dip 300 yds. in length and dropping at a gradient 3 ins. per yard. Comparing the cost of the oil engine with that of pony haulage, the saving is 1·5d. per ton in favour of the engine; and if the engine were fully employed, which it is not at present, the saving would be much more. The makers of the engine are Messrs. Robert Stephenson & Co., Ltd., of Newcastle-on-Tyne—*The Quarry*, Sept., 1901, p. 580. (Ill.)

Steam Accumulator.—*A Regenerative Accumulator.* A communication by M. W. Rateau, of Paris, read before the International Engineering Congress at Glasgow, after being translated into English, in which the author describes a novel apparatus, designed to allow, in a turbine or any other motor, the use of the exhaust steam from machines having intermittent action, such as winding engines or the reversible engines of rolling mills. This apparatus serves the purpose of a reservoir, the solid and liquid material which it contains forming a storage in which steam gathers and condenses when arriving in excess, and subsequently re-evaporises during the period when the main engine slackens or stops.—*Engineering*, Sept. 27th, 1901, p. 466. (Ill.)

4. Power and Transmission.

5. Machine Works, and Foundry.

Blast Furnace Slag.—*Disintegrating Blast Furnace Slag.* By A. D. Elbers. The author points out that, though it is well known that molten blast furnace slag of a type known as "slacking" cinder crumbles and falls

to powder in solidifying, it is not so well known that another and more common type, which hardens stone-like when it is dumped in its molten state on the cinder bank, can be made to disintegrate in a similar manner by cooling it so slowly that it will pass very gradually from the liquid to the solid state. This result can be brought about in an experimental way by collecting from 30 to 40 tons of the flushed slag while it is still quite fluid in a pit dug out on an old cinder bank, and by covering the pit in such a manner as to prevent rapid escape of heat by radiation. A more elaborate treatment is described in the U.S. patent, No. 675,205, dated May 28th, 1901. In the present article the author confines himself to the theoretical aspect of the subject.—*American Manufacturer*, Sept. 5th, 1901, pp. 1084-5.

Iron Foundries.—*Iron Foundries and Foundry Practice in the United States.* No. 1. This is the first of a series of articles describing the most modern practice of iron-founding as carried out in the United States, intended to cover, together with the articles on pipe founding, published in the 91st volume of the paper below-named, practically the whole field of iron founding.—*Engineer*, Sept. 27th, 1901, pp. 321-2. (Ill.)

Mill Testing.—*Test of New Morgan Continuous Mill.* Digest of a report of a test, conducted by R. W. Hunt & Co., Chicago, Ill., July 15th to 27th, 1901. The plant tested consists of a Morgan continuous rod mill, having 14 passes, five sets of rolls for roughing, and eight sets for finishing. The mill is operated by a single cylinder non-condensing Cooper Corliss engine. The object of the two weeks' test was to determine the efficiency of the plant, namely, the amount of fuel used in gas producers and boilers, the amount of billets heated, weight of rods rolled, together with all data relating to the operation of the plant.—*American Manufacturer*, Sept. 12th, 1901, pp. 1109-10. (Ill.)

6. Machine Tools.

Chucking Machine.—*Automatic Chucking Machine.* Description of a beautifully proportioned machine tool designed and constructed by the Cleveland Machine Screw Company, Cleveland, O. This machine has four different spindle speeds, each being brought into service automatically, and there are five independent tool spindles in the turrets, which provides sufficient tools to finish work with the greater accuracy.—*Modern Machinery*, Sept., 1901, p. 75. (Ill.)

Disk Grinders.—*Improved Disk Grinders.* The article describes a type of disk grinders that seems to possess a number of interesting features, and has become popular in American machine shops, as it closes its work quite accurately, and finishes flat surfaces with astonishing rapidity. Two of these machines are shown in the illustrations accompanying the article, being practically vertical, excepting that the one is belt-driven, and the other is direct-connected with a motor.—*American Machinist*, Sept. 21st, 1901, p. 991. (Ill.)

Die Making.—*A Combination Die for Shallow Rectangular Shells.* By William Doran. The author is of the opinion that the making of dies for metal shells is not well understood by the average die or tool maker, who, as a rule, has no opportunity of obtaining experience in this kind of work. He therefore proceeds to describe the most practical and expedient method for the construction of a combination die for the blanking and drawing of rectangular shells.—*American Machinist*, Sept. 14th, 1901, pp. 967-70. (Ill.)

Large Lathes.—*A Large German Crank-shaft Lathe.* Description of a "superb piece of tool making," the largest lathe, it seems, so far manufactured if both swing and length are taken into consideration, the latter is 11 ft. 8 in., and the extreme length between centres when the right-hand foot-stock is removed, and the other is slid down to the right-hand head-stock is 78 ft. 7 in., while the extreme length of the bed is 114 ft. 6 in. The maker is Mr. Ernst Schliese, of Dusseldorf, Germany, at whose works this tool was built, which is intended to take the heaviest marine crank-shafts in their assembled condition, and weighing up to 132,000 lbs. The gross weight of the lathe itself is 882,000 lbs.—*American Machinist*, Sept. 14th, 1901, pp. 961-3. (Ill.)

Metal Sawing.—*Machine for Sawing Metal Bars.* Description of an ingenious machine for sawing metallic bars into predetermined lengths, devised and patented by Mr. Richard B. Charlton, of Milwaukee, Wis., U.S.A.—*Modern Machinery*, Sept. 1901, pp. 83-4. (Ill.)

Radial Drill.—*The "Western" Universal Radial Drill.* Description of a full universal radial drill which, besides the usual features of such machine-tools, possesses a number of distinctive and original features.—*American Machinist*, Sept. 1901, pp. 986, 987. (Ill.)

Turret Lathe.—*Messrs. Alfred Herberts' Glasgow Exhibits.* Description of the No. 4 hexagon turret lathe and automatic stud-making machine of the above-named well-known Coventry firm, together with a No. 2 full automatic stud-making machine of the same makers.—*American Machinist*, Sept. 14th, 1901, pp. dlxxxviii, dlxxxix. (Ill.)

Rip-Saws.—*New Band Rip-Saw.* Description of a novel band rip-saw, placed upon the market by J. A. Fay & Egan Co., of No. 272, West Front Street, Cincinnati, O., which will rip from 1 in. to 10 ins. thick with equal facility without changing blades, all adjustments being made rapidly.—*Modern Machinery*, Sept. 1901, p. 84. (Ill.)

7. Refrigeration and Cold Storage.

8. Miscellaneous.

Abrasives.—*Abrasive Materials.* By Joseph Hyde Pratt. The author in a series of contributions deals with all the natural products, as well as the artificial materials, such as carbonised iron and crushed steel, used as abrasives.—*American Manufacturer*, Aug. 1st, 1901, pp. 938-43; Aug. 8th, pp. 976-78; Aug. 15th, pp. 1006, 1007; Aug. 22nd, 1035, 1036; Aug. 29th, pp. 1064, 1065. (To be continued.)

Coal-Handling Devices.—*The Coal-Handling Installation of the Boston Elevated.* Description of the power-house equipment of coal-handling machinery at the Lincoln's Wharf power station of the Boston Elevated Railway, which is in accordance with the most modern engineering practice and consists of two complete systems of Hunt standard noiseless gravity bucket-conveyors, each about 500 ft. long with a maximum lift of about 100 ft.—*Electrical World and Engineer*, Sept. 7th, 1901, pp. 396, 397.

Seamless Tubing.—"*Benedict-Nickel*" *Seamless Tubing.* As condenser tubes of brass and copper are subject to deterioration from electrolysis and other causes, a new form of condenser tube, called "Benedict-Nickel," recently introduced into this country, is attracting attention. The makers are the Benedict & Burnham Company, of Waterbury, Connecticut, U.S.A., and this contribution describes the character and use of the new product.—*Steamship*, Sept., 1901, pp. 89, 90. (Ill.)

MINING AND METALLURGY.

1. Coal and Coke.

Coal Mining.—*Working Coal Seams of Moderate Inclination in South Wales.* By Mr. Ralph Hautrey. The author, to whom the second Lewis was awarded last year by the Council of the South Wales Institute of Engineers, points out that the coal seams of South Wales are remarkable not only for their great variety in quality, thickness and inclination, but for the uncertainty or inconstancy of strata lying immediately above them. He thinks it, therefore, extremely imprudent for the engineer to lay down a hard-and-fast plan by which to work any particular seam, but expresses the opinion that "long-wall" is the most economical system in seams of "a moderate inclination, and possesses great advantages as compared with pillar-and-stall systems."—*Mines and Minerals*, Sept. 1901, pp. 59-61. (Ill.) (To be continued.)

—— *New Coal-Screening and Washing Plant at a Belgian Colliery.* J. de Jaer. Translation of an article on the subject published in the *Annales des Mines de Belgique.*—*Colliery Guardian*, Aug. 16th, 1901, p. 359. (Ill.)

2. Copper.

Cyaniding Process.—*Cyaniding Cupriferous Ores.* By L. Janin, Jr. The author describes the cyaniding method used in the Transvaal for treating their ores, the underlying principle being the property of cupro-cyanide of potassium to dissolve small quantities of copper in the form of sub-cyanide, which is afterwards precipitated.—*Engineering and Mining Journal*, Aug. 17, p. 197.

3. Gold and Silver.

4. Iron and Steel.

Blast Stoves.—*Earthenware Heating Stoves.* By F. W. Lürmann. The author deals with the construction of these stoves, and the behaviour of the earthenware material when heated. Full data of a great number of tests are given, showing the importance of using the best kind of material.—*Stahl und Eisen*, pp. 785-93.

5. Mining and Mining Methods.

Aluminium and its Derivatives.—*Methods and Results of the Study of Aluminium and its Alloys.* Abstract of a detailed report published by Professor L. Tetmeyer in the ninth issue of "Mittheilungen aus der Material Prüfungs-Anstalt am schweizerischen Polytechnikum in Zürich," giving the results of tests made by him of aluminium and its derivatives in the interests of the Aluminium Industrial Company, of Neuhausen. To this are added a few comments on the part of the editor.—*Stahl und Eisen*, Aug. 1, 1901, pp. 811-15.

Longwall System.—*A Modified Longwall System.* By Clarence R. Claghorn. Notes on the methods in use at the Vinterdale mine of the Vinterdale Colliery Company, read before the Central Mining Institute of Western Pennsylvania.—*Mines and Mining*, Aug. 1901, pp. 16-18. (Ill.)

6. Miscellaneous.

Mexican Mines.—*Mexico's Progress in Mining Matters.* By William M. Courtis. The article deals with a promising mining region recently opened, the difficulties to be overcome, notably those of transportation, and the work so far completed.—*Mines and Minerals*, Aug. 1901, pp. 1-4. (Ill.)

Zinc-Lead Ores.—*Concentrating Zinc-Lead Ores.* Description of treatment of ores consisting of galena and zincblende in the Galena-Jophes District of Moscow, and of the method of milling and of separating the pyrites which are commonly associated with these ores in such quantities as to render the ordinary methods of treatment inadequate.—*Mines and Minerals*, Sept. 19th, pp. 73-4. (Ill.)

MUNICIPAL ENGINEERING.

1. Street Lighting.

Gas Conduits.—*Subaqueous Tunnels for Gas Conduits.* By W. W. Cummings. A paper and its subsequent discussion, describing the engineering work in three river crossways, accomplished by the Massachusetts Pipe Loan Gas Co.—*Journal of the Association of Engineering Societies*, June, 1901, pp. 327-44. (Ill.)

Street-Lamp Lighting.—*Automatic Lighting and Extinguishing of Street Lanterns.* By A. Rothenbach, Jun., of Berne, Switzerland. A paper read by the author before the Gas Section of the Glasgow Engineering Congress, in which the author points out the drawbacks of ignition and extinction of street lamps by electric devices, compressed air, by using variation of pressure in the gas, by hydraulic apparatus, etc., and describes, at the request of the Gas Engineers' Association of Switzerland, a clockwork device introduced by the Actien-Gesellschaft für Automatische Zünd und Lœsch—apparate in Zürich, which, after having passed an experimental stage of three years, has been brought to such perfection as to satisfy all requirements. This apparatus consists of clockwork of the very best quality, which cannot be influenced by variations of temperature, being encased hermetically in a brass box and occupying a position in which it throws no shadow, and requires to be wound up but once in a fortnight. Each lamp can be lighted and extinguished at any time desired: any number of them may be lighted or extinguished together within a few minutes, and besides there are varieties of the apparatus, as, for instance, mechanism for lighting and extinguishing two or three flames together; another for lighting two flames simultaneously and extinguishing them singly at different times; a third, so constructed as to light and extinguish twice within 24 hours, etc. The paper referred to is full of interesting details and was highly appreciated when read at the Congress.—*Journal of Gas Lighting*, Sept. 24th, 1901, pp. 777-8. (Ill.)

2. Gas and Gas Manufacture.

Gas Manufacture.—*The Production of Illuminating Gas from Coke Ovens.* The above is the title of a very interesting and valuable paper by Dr. F. Schniewind, of New York, read before the Gas Section of the Glasgow Engineering Congress, describing a method of gas manufacture that appears to be very successful in the United States, and, where adopted, should go far in doing away with the smoke nuisance in great cities.—*Journal of Gas Lighting*, Sept. 17th, 1901, pp. 698-703. (Ill.)

Inclined Retorts.—*The Construction of Inclined Retort Carbonising Plants.* By Walter Ralph Herring, M. Inst. C. E., Edinburgh. A paper read before the Gas Section of the Engineering Congress at Glasgow, in which the author endeavours to show that the above-named installation reduces to a minimum the labour hitherto required in the charging and drawing of coal gas retorts, by employing simple and reliable mechanical devices for manipulating the material, and by taking the fullest advantage of the force of gravity.—*Journal of Gas Lighting*, Sept. 24th, 1901, pp. 767-73. (Ill.)

3. Sewerage.

Drainage.—*The Main Drainage of Woking, England.* By Nicholas Maughan. Abstract of a paper read before the Institute of Civil Engineering, and dealing with a main drainage scheme for the above-named locality, together with the general system of sewage purification.—*Engineering Record*, Aug. 24th, 1901, pp. 176-8. (Ill.)

Sewage Treatment.—*A Patent Retaining or Discharging Valve.* Description of a retaining or discharging valve designed and patented by Messrs. Mather & Platt, of Salford, with the object of providing for the retaining in contact of sewage in bacteria beds for any desired length of time, recent investigation having proved this to be necessary in a large number of cases.—*The Public Health Engineer*, Sept. 21st, pp. 234-5. (Ill.)

Sewerage.—*Bacterial Sewage Disposal in England.* Digest of a report by C. H. Rust, giving the result of his investigations in a great number of English localities.—*Engineering Record*, Aug. 10th, 1901, pp. 130, 131.

4. Water Supply.

Municipal Economy.—*The Appraisal of the Gloucester Waterworks.* This article deals with a decision by the Massachusetts Supreme Court, allowing a private water company, without exclusive franchise, a large sum for its goodwill.—*Engineering Record*, Aug. 10th, 1901, pp. 121, 122.

Supply Problems.—*The Question of Water Supply in the South-West.* By W. C. Potter. The author deals with the great dearth of water in Southern California, Arizona and New Mexico, and with the successful overcoming of this drawback to agriculture and horticulture by irrigation works.—*Engineering and Mining Journal*, Aug. 24th, 1901, pp. 225, 226. (Ill.)

5. Pavements.

Brick Pavements.—*The Expansion of Brick Pavements.* This communication deals with the results observed in many towns in which grout filter is used.—*Engineering Record*, Aug. 10th, 1901, p. 134.

RAILWAY WORK.

1. Motive Power and Equipment.

Railway Lighting.—*Railway Lighting by Acetylene.* By John S. Seymour. Short account of a system of acetylene lighting for railway cars and its alleged advantages over other methods.—*Railway and Engineering Review*, Aug. 24th, 1901, pp. 563, 564. (Ill.)

REVIEWS.

Experimental Engineering. Vol. I. A Treatise on the Methods and Instruments used in Testing and Experimenting with Engines, Boilers, and Auxiliary Machinery. By W. W. F. Pullen, Wh. Sc., M. I. Mech. E., A. M. Inst. C. E. The Scientific Publishing Company, Manchester, 1901.

One of the most prominent features of technical education in the present day is the attention given to experimental work, and no reasonable doubt can be entertained as to the value of such research as a preparation to the student for the labours which await him in after life. No one need expect educational establishments to turn out students in the form of the finished article, so to speak, but they should be thoroughly equipped with such knowledge as will enable them to appreciate all matters of technical interest that are encountered in practice, and so to become good practical as well as theoretical engineers. The necessity for knowledge of the kind is more than ever needed in the present day, because most large engineering works are now equipped with experimental departments of their own. As Professor of Engineering at the South-Western Polytechnic, Mr. Pullen naturally takes much interest in the training of young engineers, and we have no doubt his last work, like others that have preceded it, will be duly appreciated by his students. In the earlier chapters dealing with calculating and averaging machines, the theoretical work upon which they are based receives due notice, because such matter is not invariably found in text-books previously in use. The author had also in view the fact that the operator is always more successful when he is thoroughly acquainted with the principles of the instruments employed. But Professor Pullen has done more than merely to explain theory; he has been careful to point out in what manner testing instruments may be misapplied or misused; and this caution is the more necessary for the reason that in all testing operations the accuracy of the apparatus must constantly be checked.

In Chapter I., after mentioning in a general way the object of a test, the steps in an experiment, and possible errors, the author commences by a brief explanation of the principle underlying the construction and application of the slide rule. In this connection some brief references are made to the ordinary straight slide rule, the watch form of calculator, and the Fuller spiral slide rule. The remainder of the chapter is devoted to discussion of various forms of planimeters, and finally to a few words of caution as to possible and probable sources of error, and the best means of checking the accuracy of the instruments. The measurement of pressure and temperature forms the subject of Chapter II., and we find some familiar types of pressure gauges illustrated and described. Methods of measuring pressure by columns of liquid, blast gauges, and apparatus for testing gauges are clearly dealt with in the same chapter, as also is the measurement of temperature by mercurial, air, thermo-electric, and platinum thermometers. After recording some tables relative to the properties of matter and energy, the author proceeds, in Chapter IV., to describe different types of speed indicators. Several speedometers are made the subject of notice, but for details we must refer our readers to the work itself.

With Chapter V. commences a consideration of the measurement of power, power being defined "as the rate of doing work per unit of time." Speaking of the fraction of the energy received by a machine that is given out by the machine in doing useful work, the author points out that "the ratio: useful work done by a machine ÷ total energy received by a machine is called the mechanical efficiency of the machine." Taking the work done during one minute, the mechanical efficiency is expressed as: "the horse-power at which a machine gives out energy ÷ the horse-power at which a machine receives energy." Thus the author leads his reader to see that the numerator of this fraction is measured by the speed indicator and the dynamometer, and a useful connection is established between the present and the preceding chapter. Friction brakes, or absorption dynamometers, first occupy attention. Of this type, the familiar rope brake is easy of construction, and under ordinary circumstances it is both convenient and efficient. Professor Pullen furnishes drawings and description sufficient to enable anyone to make for himself a dynamometer of this kind; he gives simple and intelligible instruction for its employment, and rules by which results may be correctly interpreted. An ingenious form of water-cooled brake-wheel, designed and supplied to the author by Messrs. Ransomes, Sims & Jeffreys, has been found to work perfectly, and its convenience for frequent and rapid stopping has been generally appreciated in experimental work. Amongst other forms of the absorption dynamometer, the Appold compensating brake is worthy of notice. In this appliance the wheel is surrounded by a number of timber segments connected by two thin bands of steel, the ends of which are joined by a right and left hand screw at one side of the circle, and by pivoted connections to a rod supporting weights at the other side. Just beneath the right and left hand screw is a bracket to which is attached the rod carrying the load weights, and the rod is prolonged through a floor plate for the purpose of safety. Professor Barr has suggested a modification of this type of brake, but the alteration does not affect the principle to any material degree. The dynamometer designed by Mr. Coope is another example described by the author, and its advantages are that a *constant load* and remarkable smoothness of running are ensured. The brake strap is of segmental construction, somewhat like that in the last-mentioned brake, but with a spring on the screw giving a flexible grip on the wheel. The strap is divided into two parallel strips coupled at two points, and between the two portions ropes are attached on which weights are hung. In calculating the horse-power indicated by this brake, it must be remembered that the right and left hand weights are to include the weight of the material by which they are sus-

pended. Then, if a be the distance from the wheel centre to the centre of the weight W, and b the corresponding distance for the weight Q; while R represents the resistance of friction, r the radius of the wheel, and N the number of revolutions, $R = Wa - Qb \div r$, or b.h.p. $= 2\pi N(Wa - Qb) \div 33{,}000$. Professor Pullen also describes an absorption dynamometer where the segmental strap is encircled with a number of $\frac{3}{8}$-inch steam tubes, and he refers to the ingenious water-jacketed brake bands used by Professor Goss, and by Professor Carpenter of Cornell University. The water spray brake band is another form which in the opinion of Professor Goss leaves very little to be desired. The latter types are of course designed so as to remove rapidly the heat generated by friction. A brake designed by Mr. Leavitt, to determine the power of a small high-speed motor during a very short run, resembles in principle the well-known water-churn by means of which Joule arrived at the mechanical equivalent of heat. The Alden dynamometer, made by Messrs. Riehle Bros., of Philadelphia, is of the *constant load* type and is generally fixed on the shaft of the motor to be tested. In this apparatus copper plates are pressed against a central disc by water pressure. The friction thus generated produces heat, which rapidly flows through the copper plates into the water, which thus exercises the double function of keeping the brake cool as well as of producing friction. A form of brake totally unlike any of those previously described by the author is one invented by the late Dr. W. Froude, F.R.S.; and an interesting modification of the same apparatus is that of Professor Reynolds, made by Messrs. Mather & Platt. Both of these are considered in detail by Professor Pullen, to whose pages we refer our readers.

Coming to the second class of dynamometers, in which energy is transmitted through mechanism registering the force exerted in doing useful work, we observe several of the best known types of apparatus are very clearly explained. Amongst these are the Tathan, the Flather, the Morin, and the Stroud dynamometers; and the chapter concludes with a brief reference to the use of the dynamo and motor as dynamometers. From the outline we have given of the preliminary chapters of the work, it must be evident that no pains have been spared to place at the disposal of the student adequate if not exhaustive information as to the principles of the appliances that are used in one important branch of experimental engineering.

Chapter VI. marks the opening of an inquiry into the principles, construction, and use of the indicator. Before proceeding to describe the different forms of indicator, the author makes clear, briefly though lucidly, the manner in which this beautiful instrument is applied.

Errors are always possible when testing instruments are employed, and they are certain to occur unless accuracy of the apparatus be constantly checked. Much attention has been devoted by eminent engineers to the testing of steam-engine indicators, and some interesting examples of the apparatus devised for testing indicators are to be found in the chapter now claiming attention. In addition to the errors revealed by appliances of the kind there are others due to various causes. The author instances oscillation of the recording pencil as producing a distorted diagram, and whilst showing that friction tends to destroy vibration, it has the effect of causing other errors. A bad case of indicator sticking is illustrated, where false lines resulted in the diagram. This is cited as an instance of the great care necessary when using high-class and delicate instruments. Some other adverse influences receive mention, such as inertia of the paper drum, drum friction, excessive length of the indicator cord, displacement of paper on the drum, throttling in the pipe communicating with the cylinder, unsuitability of the pipe connections, and stretching of the indicator cord. Finally, it is pointed out that when diagrams are copied the wrong lines are generally very easy to follow, especially if the diagrams are not new.

The analysis of the indicator diagram forms the subject of Chapters VIII. and IX., a most useful portion of the book, wherein the cardinal points of steam-engine diagrams are discussed in a practical manner, and over eighty reproductions are given of diagrams under a great variety of conditions. It is worthy of note that the author gives hints that ought to be of material assistance to beginners in indicator work. At the end of Chapter IX. will be found a brief but interesting paragraph relating to valve chest diagrams, and illustrating the fluctuations of pressure taking place in selected examples. As the author remarks, such diagrams in a measure afford an indication of the adequacy of steam pipe sectional area. Chapter X. opens with a series of examples showing how the adjustment of the valves of a steam-engine may be added by the use of the indicator. The illustrations contained in this chapter were taken during the adjustment of a slide valve, and they therefore form suitable exemplifications of the subject. The chapter concludes with some notes upon the irregular results following the employment of a badly adjusted or designed valve-gear. Pump diagrams are discussed in Chapter XI., following which is a short chapter on miscellaneous diagrams, including gas-engine diagrams, and combined diagrams from compound engines.

The methods adopted for measuring the calorific value of steam are set forth in Chapter XIII. followed in the next chapter by a consideration of the different types of measuring apparatus for steam and water, ranging from the simple and primitive measuring tank to the beautiful water meter invented by Mr. Schonheyder. Chapter XV. is occupied with a consideration of the distribution of energy on its way through the steam engine. The first portion of the chapter deals with the "balance sheet," or statement of the receipt and expenditure of energy—a very necessary record in scientific tests of engines. Thermal efficiency and Hirn's analysis receive attention in the latter part of the chapter, which will well repay perusal. Boiler-testing and gas-engine experiments form the subjects of Chapters XVI. and XVII., and although the treatment is rather brief it has the merit of being lucid, and may be expected to

arouse the interest of the student, and to stimulate his appetite for further intellectual food of the same kind. The work concludes with an extended description of some typical experimental installations, and with the results of some typical experiments. This section is well illustrated, and should give the student a very fair idea of the nature of the work awaiting him. Taking Professor Pullen's book as a whole, it bears evidence throughout of the most thoughtful treatment, and of a clear appreciation of the difficulties likely to be encountered by the beginner. In our opinion it forms a welcome and valuable addition to technical literature of an educational nature.

Papers on Mechanical and Physical Subjects.—By Prof. Osborne Reynolds, F.R.S., etc. Vol. II. xii and 740 pages. Cambridge University Press, 1901. Price 21*s.* net.

The second volume of Professor Reynolds's papers contains interesting and important contributions to knowledge, ranging over a very considerable area. It illustrates even more fully than the first volume, which has already been reviewed in our columns, a very noteworthy characteristic of his work. The Professor, in addition to being an experimentalist of the first order, is a mathematician of no mean ability, but his mathematical investigations are invariably employed to co-ordinate and extend the results of his observations, and to guide them into new channels. In setting forth his results, the mathematical treatment is so far separated from the experimental discussion of engineering questions that the engineer whose mathematical knowledge is of the smallest will have no difficulty in making himself acquainted with the results obtained and forming his own judgment upon them from the point of view of their experimental confirmation.

The volume opens with some interesting papers contributed to *The Engineer* about twenty years ago, on the fundamental limits to speed, in which he set forth the principles to be taken account of in "balancing" the reciprocating portions of machinery, more especially steam locomotives, and also the considerations determining the construction of rolling stock for steady running at high speeds. Many of the improvements which have been made during the last two decades owe their origin to investigations which were directly or indirectly the outcome of their publication.

A large proportion of the papers collected together in this volume originated in attempts to elucidate obscure points in hydrodynamical theory. The first of these is entitled "An Experimental Investigation of the Circumstances which determine whether the Motion of Water shall be Direct or Sinuous, and of the Law of Resistance in Parallel Channels." It was in this investigation that Professor Reynolds first made use of his beautiful method of colour bands for experimentally investigating the flow of water and other liquids.

It was in the course of investigations into the possible constitution of fluid media that he was led to the discovery of "dilatancy" as a property of media composed of rigid particles in contact. This property explains in a very simple manner a number of well-known phenomena occurring, in connection with wet and partially wet sand as found on the seashore. The Professor explains by its aid a trick which is well known to corn chandlers who sell corn by measure. The measure is over filled and the surplus corn removed by striking the measure with a small stick. If this stick is put end on into the measure before beginning to fill it, then gently withdrawn, and the top struck, the result will be that the measure will only be nine-tenths full, as may be shown by shaking it. These investigations and considerations connected with the general theory of waves in liquid media led to the appointment of a Committee of the British Association, with Professor Reynolds as its leading spirit, to investigate the action of waves and currents on the beds and foreshores of estuaries by means of working models. The reports of this Committee, containing results of the greatest practical value, form a considerable portion of the present volume.

A very interesting theoretical paper dealing with a subject of great practical importance is one which bears the title, "On the Theory of Lubrication and its application to Mr. Beauchamp Tower's Experiments, including an Experimental Determination of the Viscosity of Olive Oil."

The author states that, on reading the reports of Mr. Tower's experiments on lubrication, which were presented in 1883 and 1884 to the Institution of Mechanical Engineers, it occurred to him that, in the case of the oil bath, the film of oil might be sufficiently thick for the unknown boundary actions to disappear, in which case the results would be deducible from the equations of hydrodynamics.

The application of the hydrodynamical equations to circumstances similar, in so far as they were known, to those of Mr. Tower's experiments, at once led to an equation between the variation of pressure over the surface, and the velocity, which equation appeared to explain the existence of a film of oil at high pressure between journal and bearing, as was observed by Mr. Tower. This film was maintained by the motion of the journal in spite of the presence of the oil in the crown of the bearing, rising as high as 625 lbs. per sq. in. above that in the oil-bath, as was shown by actual measurement to be the case. The approximate variation of the viscosity with speed and load was ascertained with the aid of the results of an experimental determination, undertaken for the purpose, of the relative viscosities of olive oil and water of different temperatures. Taking these variations of viscosity into account, the results of the hydrodynamical theory are in complete accordance with those experimentally obtained by Mr. Tower.

The hydrodynamical theory is also found to account for some very singular phenomena observed in connection with the unequal wearing of brasses.

Two very valuable papers are those on "The Theory of the Steam Engine Indicator," and "The Errors in Indicator Diagrams," by Prof. Reynolds and Prof. D. W. Brightmore.